

RECORDS OF THE GEOLOGICAL SURVEY OF INDIA.

Part 1.]

1910.

[August.

PRE-CARBONIFEROUS LIFE-PROVINCES. BY F. R. COWPER
REED, M.A., F.G.S.

INTRODUCTION.

THE problems of the geographical distribution of life in the Palæozoic seas are continually being brought nearer satisfactory solution by the detailed palæontological study of the ancient deposits in distant lands; and during the last few years a considerable mass of new facts has been accumulated which require some of our existing conceptions to be modified. A survey of the current views on the subject is therefore desirable. This revision is particularly requisite in connection with the continent of Asia, where investigations have been rapidly proceeding with remarkable results. By the concurrent advance in our knowledge of the principles which guide the correlation of formations and the migrations of faunas (1), of the dependence of organisms on their environment, of the value of isolation as a factor in evolution (2, 3), of the relative importance of various physical factors, and of the distinction of the several biological elements in a fauna, we are now better enabled to approach the questions connected with the past distribution of organisms.

It is no longer possible to maintain that the diffusion of Lower Palæozoic life was uniform; there is no such thing as a universal fauna during any geological period; differences in composition or character, of greater or less degree, are always apparent, even when dealing with the faunas of deposits which were formed in the same marine basin and under similar conditions, so far as their lithological character indicates. On the other hand heterochronous faunas are found to be similar

in distant regions ; and heteroethonous faunas (4), not in genetic series with their immediate predecessors, introduce a new problem. While special types of faunas are recognised to be frequently restricted to limited areas, widely diffused organic assemblages also occur and are regarded as evidence of free intercommunication in the seas and of the absence of effective barriers. The effects of the immediate physical environment are sought for in special local adaptations amongst members of the fauna, apart from a general progress in organic evolution which is acknowledged to be traceable from period to period, though not at a uniform rate in all parts of the world or with precisely the same features under all conditions.

A zoo-geographical student pays special attention to localised or provincial types of faunas, and in seeking to apply the lessons of present marine distribution to the problems of the past, it is necessary to discriminate between the various elements in the fauna grouped according to their presumed mode of life, their autoethonous or heteroethonous ancestry, their adaptation to peculiar local conditions, and their connection with the nature of the sedimentation, and to separate the restricted from the widely-distributed or cosmopolitan members. When such a preliminary classification has been made, the strength and character of the local or provincial elements become apparent.

A primary difficulty which confronts us is our frequent ignorance of the mode of life of some important groups or families or genera amongst the Palæozoic faunas. We have to trust for help in these cases not only to the evidence of the general structure of the organisms and to the analogy of allied or similarly built living types, but also to their mode of occurrence, their association with other organisms, the nature of the sediment in which their remains occur and the individual peculiarities of the fossils, such as their state of preservation, frequency, local abundance, etc. A case in point is that of the trilobites ; but, as with modern crustacea, it is probable that in such a large and varied group there were shallow water forms, deep water forms, and open sea forms, some inhabiting clear and others frequenting muddy waters, while we cannot doubt that they differed in their powers of locomotion and migration (4a).

When we have satisfied ourselves that the fauna of the beds of any particular age and area is of a local or provincial type with marked peculiarities in composition and character, such as the presence of local genera or species, we have to seek to discover the

previous paper, yet the absence of anything approaching a definite anticline in them precludes much hope of obtaining oil, save in shallow wells. There is plenty of evidence that oil could be obtained in shallow Burmese wells, but the water level of the country seems to be too high to obtain oil at a depth by boring.

A few years ago many wells were drilled around Banbyin and Padaukpin, but they have all been abandoned, and I do not think that the locality offers any inducement for further experimental drilling.

FOSSIL FISH TEETH FROM THE PEGU SYSTEM, BURMA.
 BY MURRAY STUART, B. SC., F.G.S., *Geological Survey
 of India.* (With Plates 25 to 27.)

Prome District.

THE following teeth were obtained by me this year from a bed near the base of the Lower Prome series opposite Prome, situated on the bank of the Irrawaddy just below the Sinde Bungalow :—

Carcharias (Aprionodon) sp.—These teeth, which are very numerous in this bed, resemble very closely the species *Carcharias (Aprionodon) frequens* Dames, found in the Eocene of Egypt,¹ but differ in having the vertical furrow in the base less distinctly marked (Pl. 25, fig. 1-3).

Carcharias (Prionodon) sp.—The two teeth figured here (Pl. 25, fig. 4) belong to the genus *Carcharias* and to the sub-genus *Prionodon*. They resemble somewhat the teeth of *Carcharias (Prionodon) gangeticus* Müller and Henle, but are much smaller.

Galeocерdo latidens Ag.—This species is of frequent occurrence in this bed. The tooth figured is a broken specimen of a lateral tooth. It resembles exactly a fossil found in the Province of Mozambique.² Several other teeth of this species were found, but they broke into fragments while being extracted from the sandstone (Pl. 25, fig. 5). The presence of *Galeocерdo latidens* in these rocks indicates an Eocene or Oligocene age,³ while the teeth which I have referred to the genus *Carcharias (Aprionodon)*, from their similarity to *Carcharias (Aprionodon) frequens*, seem to indicate a similar age.

Since I have shown in a previous paper that these teeth occur in a bed some 3,000 feet below the bed containing *Ostrea latimarginata* Vred.⁴ (which is at latest lowest Burdigalian), the evidence of age given by these teeth conforms perfectly with the view that these beds are at latest Oligocene.

¹ F. Priem : Sur les Poissons fossiles éocènes d'Egypte et de Roumanie (*Bull. Soc. géol. de France*, 3e série, t. XXVII, 1899, p. 243-244, pl. II, fig. 8-15).

² F. Priem : Poissons tertiaires des possessions Africaines du Portugal. (*Comm. da Commissao do Servico geologico de Portugal*, Tom. VII, Fasc. I.)

³ F. Priem : *l. c.* p. 79.

⁴ *Supra*, p. 274.

Padaukpin and Banbyin in the Thayetmyo District.

Carcharodon megalodon Ag.—This specimen (Pl. 25, fig. 6) was obtained by Dr. Noetling from the Pegu shales at Padaukpin and is described by him in his monograph.¹ As the original lithograph in the monograph is somewhat indistinct, I have refigured the specimen from a photograph.

Hemipristis serra Ag.—These teeth are very common throughout the shales around Padaukpin and Banbyin. It is a species characteristic of Miocene and Pliocene age² (Pl. 25, figs. 7 and 8).

The presence of these two forms indicates a Miocene or Pliocene age³ and thus confirms the view given by me in the preceding paper that these rocks are the upper development of the Kama clays. These two forms, together with the form referred to *Lucina globulosa*, which was found by Mr. Dalton in these shales³, definitely indicate that their age is Middle Miocene. *Hemipristis serra*, owing to its abundance, will probably prove of great importance in proving the presence of equivalents of the Kama clays at localities far apart from each other.

Minbu and Yenangyat Oilfields.

Lamna spallanzanii Bonaparte (Pl. 25, figs. 9 and 10). This form was obtained by Noetling from the above-mentioned oilfields and is figured and described by him in his memoir.⁴ It is synonymous with the forms *Oxyrhina spallanzanii* Bonaparte, and *Oxyrhina gomphodon* Müller and Henle, and has hitherto been found to have a range extending over Pliocene and recent times.⁵

The existence of this form in the faunas of these three oilfields indicates that the rocks in which it occurs are at least high in the Miocene, if not actually in the Pliocene, thus corroborating the view put forward by me in the preceding paper that the rocks of these fields are of later age than the zone of *Arca theobaldi* (base of the Kama clays).

¹ F. Noetling: *Pal. Indica*, New Series, Vol. I, pt. 3, p. 374, pl. XXV, fig. 8.

² Priem: *I. c.* p. 79.

³ *Quart. Journ. Geol. Soc.*, Vol. LXIV, pt. 4.

⁴ F. Noetling: *Palaeontologia Ind.*, New Series, Vol. I, pt. 3, p. 28-36, pl. XXV, figs. 4, 5, 6.

⁵ C. R. Eastman: *Palaeontographica*, XLI, 1894, p. 189-191.

Pakokku District.

Carcharodon megalotis Agassiz. (Pl. 25, fig. 2).—This form was found by Mr. G. de P. Cotter in the stream (Dandin chaung), north of Nyaungbinzauk ($21^{\circ} 42'$, $84^{\circ} 42'$) in beds which he identifies as the basal beds of the Irrawaddy series (Fossil-wood series of Theobald).

Otodus appendiculatus Agassiz.—To this species I have referred a form obtained by Mr. Cotter (Pl. 25, fig. 11) from beds occurring near Myaing which he assigns to the Pegu system. It is a form which is abundant in the Cretaceous system in England and on the Continent.¹

Singu Oilfield.

The fossil fish teeth which I describe below were, with one exception, obtained from the Pegu beds exposed in the Singu Oilfield, by Mr. S. Sethu Rama Rau, in the season 1907-08. They contain several forms which have hitherto not been found in Burma.

Oxyrhina spallanzanii Bonaparte.—These teeth were found in abundance in two fossil zones, situated low in the field, some considerable distance below the zone of *Meiocardia metavulgaris*, described by Noetling. As I have already shown these teeth are thought to range over Pliocene and recent times.² In his memoir on the Fauna of the Miocene beds of Burma, Noetling describes this form as occurring in both the zones, *Mytilus nicobaricus* and *Meiocardia metavulgaris*, but the specimens figured by him come from another district, Minbu.³

Carcharodon lanceolatus Agassiz.—The species described by Agassiz under the above name is characterised by its slender shape, and also, equally, by the existence at the base of the enamel of two distinct grooves. The figured specimen, which was found in the zone of *Meiocardia metavulgaris*, is not quite so slender in shape as the one figured by Agassiz, but the presence of the two

¹ Agassiz: *Poissons Fossiles*, pt. III, p. 270. Compare also Theobald's views as to the very Cretaceous aspect of many squaline teeth from the Pegu system (*Memoirs, Geol. Surv. India*, Vol. X, pt. 3, p. 87).

² *Supra*, p. 293; also C. R. Eastman: *Beiträge zur Kenntniss der Gattung Oxyrhina—Palæontographica*, XLI, (1894), Stuttgart, pp. 190 and 191.

³ *Pal. Ind.*, New Series. Vol. I, pt. 3, p. 32, 33, pl. XXV, figs. 4, 5, 6.

distinct grooves at the base of the enamel on the front of the tooth suffices to assign it definitely to this species. The form described by Agassiz came from the Eocene at Kressenberg.

Carcharias (Aprionodon) frequens Dames.—*Sitzungab. k. preuss. Akad. Wiss.*, 1883, pt. 1, p. 143, Pl. 3, fig. 7. This species is characterised by the breadth of the root, which is at least double that of the height of the tooth, and also by the existence of a distinct vertical furrow situated in the middle of the inner face of the root. Some eight specimens of this species, three of which are figured (Pl. 26, figs. 5, 6 and 7), were obtained from a bed situated between the zones of *Mytilus nicobaricus* and *Meiocardia metavulgaris*.

Carcharias (Prionodon) egertoni Agassiz.—

Syn. *Carcharias nimor* Ag. in Egert. catal.

Corax egertoni Agassiz, 1843, Poiss. Foss., Vol. III, p. 228, Pl. XXXVI, figs. 6 and 7.

This species is described as follows:—"Upper teeth broad, triangular, prominently serrated, both margins slightly concave. Lower teeth probably narrower than the upper, robust and prominently serrated." The specimens obtained by Mr. S. Sethu Rama Rau come from the zone of *Meiocardia metavulgaris* and from two higher zones situated between it and the zone of *Mytilus nicobaricus*, the uppermost of these intermediate zones being the one from which he obtained the species.

Carcharias (Aprionodon) frequens Dames.—The specimens obtained resemble very much the one figured in "Geological Survey of Maryland, Miocene plates," as coming from the Miocene system¹. (Pl. 26, figs. 8, 9). From its similarity to the above form I have included the specimen shown on fig. 10 in this species. It differs from the others which I have figured, in that the length of the crown on the inner face of the tooth is less, and the height of the root greater; the front face of the tooth is however identical with that of the typical *Carcharias (Prionodon) egertoni*. Since Mr. S. Sethu Rama Rau obtained abundant specimens belonging to both these forms and also several specimens which are intermediate between the two, I have no hesitation in referring them all to the same species.

¹ *Maryland Geol. Surv., Miocene plates*, Pl. XXXII, fig. 1.

Carcharias (Prionodon) collata (ex. Cope MS).—This species is described first in “Geological Survey of Maryland, Miocene text,” as:—“A species of moderate size, the teeth comparatively stout, with a narrow, usually erect crown, strongly convex on its inner and slightly so on its outer face; apex sometimes curved slightly inwards or backwards; coronal edges with extremely minute serrations disappearing towards the base. The enamel at the base of crown extends much lower down in the middle of the outer than on the inner face. The root is considerably elongated, large and symmetrical.”¹ Only one specimen (Pl. 26, fig. 12) of this species was obtained; it was found in the bed that yielded the specimens of *Carcharias (Aprionodon) frequens*. This form occurs in the Miocene of Maryland and specimens are preserved in the collections of the Maryland Geological Survey and the Philadelphia Academy of Natural Sciences.

Hemipristis simplex, n. sp. (?).—I have figured under this name a specimen obtained from the above-mentioned bed that yielded *Carcharias (Aprionodon) frequens* Dames, *Carcharias (Prionodon) egertoni* Ag., and *Carcharias (Prionodon) collata* (ex Cope M.S.) It resembles strongly *Hemipristis serra* Ag., differing in the entire absence of any indications of serration along the marginal edges of the tooth. It is stout and narrow, convex on both faces, about 2 cms. in height measuring from the apex to the base of the enamel. The lateral edges of the crown are sharp from the apex to a point level with the top of the swelling on the inner face of the root, below which the crown is rounded. The swelling on the inner face of the root bears a deep longitudinal notch, resembling *Hemipristis serra* in this.

Two specimens only were obtained; the one which I figure (Pl. 26, fig. 13), and another specimen, the uppermost portion of whose crown was missing. Consequently I had a vertical section cut of the less perfect specimen, and the microscopical examination (Pl. 27, fig. 1) confirmed my view that this specimen must be classed with the genus *Hemipristis* Agassiz. Since the specimen figured is in very good preservation and shows no sign of having been worn, it cannot very well be classed as *Hemipristis serra*, which it most resembles in form, because one of the distinguishing characteristics of *Hemipristis serra* is the form and size of the

¹ L.c. p. 85, Plate XXXII, figs. 3 to 5.

serrations along its lateral margins. In 1878, Probst described and figured as *Hemipristis serra* a very inclined tooth which is also destitute of all marginal serrations (*Württ. Jahresh.*, Vol. XXXIV, p. 143, pl. 1, fig. 50); but there is this difference between it and the one described above, that the sharp edge which runs downwards from the point in one piece, does not fall or cease in the specimen described by him, whereas it does cease some distance above the root in the specimen described by me. Another reason which makes me unwilling to refer this tooth to the species *Hemipristis serra* is that it is an almost erect specimen and therefore probably an anterior tooth, and the anterior teeth of *Hemipristis serra* Ag. have strongly marked serrations on both marginal edges. I have therefore named it provisionally *Hemipristis simplex*, until some more specimens may be obtained and further light thrown on the subject.

Hemipristis serra Agassiz.—Two broken specimens of lateral teeth were obtained from the bed which yielded the previously described specimens of *Hemipristis simplex*, and another specimen of a lateral tooth and a broken specimen of an anterior tooth were obtained from the zone of *Meiocardia metavulgaris*. The specimen figured is from the latter zone (Pl. 26, fig. 14). The specimens of *Hemipristis serra* previously obtained from Burma by Dr. Noetling and myself were all obtained from the Padauk-pin area, Thayetmyo, and have been discussed by me above.

Sphyrna prisca Agassiz?—

Syn. *Carcharias gangeticus* M. & H., F. Noetling :
Fauna of the Miocene of Burma, *Pal. Ind.*, New Series,
Vol. I, p. 375, Pl. XXV, figs. 11-15.

No specimens of this species were found by Mr. S. Sethu Rama Rau. I have examined the specimens which were referred by Noetling to the species *Carcharias gangeticus* M. & H., and, on comparison with the sets of teeth of this species which are preserved in the Indian Museum, I cannot confirm his identification. Noetling's specimens are considerably smaller than the teeth of a full grown *Carcharias gangeticus*, and even if it is possible that all his specimens come from half grown or smaller fish, which is not at all likely, since he obtained more than three dozen specimens, there is even then a distinct difference between his specimens, among which are some quite indistinguishable from the typical *Apriodon*, and the teeth of *Carcharias gangeticus*. Noetling's specimens

are more slender and have their marginal serrations less distinct and less uniform and their anterior margin more concave than is the case in the species *Carcharias gangeticus*. His specimens correspond more closely with the species *Sphyrna prisca* Ag., the forms figured by him in figs. 12 and 13 resembling very closely the form figured by Agassiz on Tab. 26a, (Vol. III), fig. 35, while the forms figured by Noetling in figs. 14 and 15 resemble the form figured by Agassiz as *Sphyrna lata*; the latter, however, is looked upon as a very doubtful species. As it is exceedingly difficult to distinguish the genus *Sphyrna* Rafinesque from *Carcharias* by means of isolated teeth, it is possible that Noetling's specimens should be referred to some species of this latter genus, but they cannot be regarded as belonging to the species *Carcharias gangeticus* M. & H.; whether, in any case, they represent a living form cannot be decided until the investigation of the sharks of the Bay of Bengal, at present being conducted, is complete.

The presence of the forms *Oxyrhina spallanzanii* Bon., *Hemipristis serru* Ag., *Carcharias (Prionodon) egerioni* Ag., *Carcharias (Prionodon) collata* (ex. Cope MS.), indicates a Miocene age for these rocks in the Singu oilfield and therefore an age not older than the Kama clays, a view which has already been advanced by me from stratigraphical reasons, and which has already received some support from Noetling's reported discovery of *Oxyrhina spallanzanii* Bonaparte, in both the zones *Mytilus nicobaricus* and *Meiocardia metavulgaris*.¹

Pagan Hills.

In addition to the above described forms I have recently had sent to me for determination the following form from the geological collection of the Burma Oil Co. at Yenangaung. It was obtained by Mr. Macrorie from one of the lowest beds exposed in the Pagán Hills.

The Pagán Hills are situated about twelve miles north-east of the Singu anticline and are reported by Mr. E. Grimes to consist of beds of the Pegu system of which neither the top or bottom beds are exposed.²

¹ *Supra*, page 288.

² Grimes, G. E. : *Geology of parts of the Myingyan, Magwe and Pakokku districts -- Memoirs, Geol. Surv. Ind., XXXVIII, p. 60.*

Carcharodon angustidens Agassiz.—The species is described by Agassiz as follows: "It is distinguished from most other forms of *Carcharodon* by its very slender shape. Its shape is that of an isosceles triangle, and seen in profile from the side view it is practically vertical. Its thickness decreases insensibly towards the apex. The external face shows a slight longitudinal ridge which extends to the apex. Towards the lateral margins the same face is depressed, which gives it an appearance of being undulated. The inner face is convex. The marginal serrations of the enamel are distinct and uniform. The angle formed by the '*bourrelets lateraux*' and the principal cone is acute whereas the angle in other species, and notably in *Carcharodon auriculatus* is a very open angle."

The specimen figured (Pl. 26, fig. 3) is very similar to the form figured by Agassiz on Tab. 30, fig. 3, under the name *Carcharodon lanceolatus*, but which he afterwards referred to this species (Poiss. Foss., Vol. III, p. 255). The specimen figured by me however has sufficient of the root and '*bourrelet lateral*' preserved to prevent any confusion between the two forms.

A. Smith Woodward, in his catalogue of the fossil fishes in the British Museum (1889), classes, amongst other forms, the *C. angustidens*, *C. lanceolatus*, and *C. megalotis* described by Agassiz, as synonymous with *Carcharodon auriculatus* Blainville¹; but Maurice Leriche, in his paper on '*Les Poissons éocènes de la Belgique*', published in 1905², disagrees with the synonymy suggested by A. Smith Woodward and takes away from the list of forms which he published as being synonymous with *Carcharodon auriculatus* Blainville, the following:—

<i>Carcharodon angustidens</i>	Agassiz.
<i>Carcharodon turgidus</i>	"
<i>Carcharodon lanceolatus</i>	"
<i>Carcharodon megalotis</i>	"

Since there is a majority of opinion against the synonym suggested by A. Smith Woodward, I have described the forms *C. angustidens* Agassiz, *C. lanceolatus* Agassiz, and *C. megalotis* Agassiz, as three separate species, rather than classing them all as *C. auriculatus* Blainville, feeling that, owing to the uncertainty

¹ *L.c.* page 412.

² M. Leriche: '*Les Poissons éocènes de la Belgique*.' *Mém. Mus. Roy. Hist. Nat. de Belgique*, III, 1905.

which prevails, I cannot add confusion by so doing if the synonymy suggested by A. Smith Woodward is at any future time established; whereas if I class these three forms as *C. auriculatus* and the synonymy suggested by A. Smith Woodward is ever conclusively contradicted, I should have only added confusion and left it necessary for them to be redetermined.

The type form *C. angustidens* described by Agassiz comes from the Eocene of Kressenberg, though not from the same bed as the type specimen of *C. lanceolatus* Agassiz.

EXPLANATION OF PLATES.

PLATE 25.

- Figs. 1, 2, 3.*—*Carcharias (Aprionodon)* sp., natural size.
Fig. 3a.—Same twice, twice natural size.
 „ *4.*—*Carcharias (Prionodon)* sp., natural size.
 „ *5.*—*Galeocerdo latidens* Agassiz, natural size.
 „ *6.*—*Carcharodon megalodon* Agassiz, natural size.
Figs. 7, 8.—*Hemipristis serra* Agassiz, natural size (Padaukpin).
Fig. 9.—*Oxyrhina spallanzanii* Bonaparte, natural size (Minbu).
 „ *9a.*—Same tooth, back view.
 „ *10.*—*Oxyrhina spallanzanii* Bonaparte, natural size (Minbu).
 „ *10a.*—Same tooth, back view.
 „ *11.*—*Olotus appendiculatus* Agassiz, natural size.
 „ *11a.*—Same tooth, back view.
 „ *12.*—*Carcharodon megalotis* Agassiz, natural size.
 „ *12a.*—Same tooth, back view.

PLATE 26.

Teeth from Singu Oilfield and Pagan Hills.

- Figs. 1, 2.*—*Oxyrhina spallanzanii* Bonaparte.
Fig. 3.—*Carcharodon angustidens* Agassiz.
 „ *3a.*— „ „ Agassiz (inner face)
 „ *3b.*— „ „ „ (side view).
 „ *4.*—*Carcharodon lanceolatus* Agassiz.
 „ *4a.*— „ „ „ (inner face).
 „ *4b.*— „ „ „ (side view).
Figs. 5, 6, 7.—*Carcharias (Aprionodon) frequens*, Dames.
Fig. 8.—*Carcharias (Prionodon) egertoni*, Agassiz (inner face).
 „ *8a.*— „ „ „ (outer face).
Figs. 9, 10, 11.—*Carcharias (Prionodon) egertoni*, Agassiz (inner face)

Fig. 12.—Carcharias (Prionodon) collata (ex Cope MS.

„ 12a. „ „ „ „ (inner face).

„ 13.—*Hemipristis simplex*, n. sp. (?).

„ 13a.— „ „ „ „ (inner face).

„ 13b.— „ „ „ „ (side view).

„ 14.—*Hemipristis serra*, Agassiz.

PLATE 27.

Vertical section of *Hemipristis simplex*, magnified sixteen diameters.

THE NORTHERN PART OF THE YENANGYAT OILFIELD.
 BY G. DE P. COTTER, B.A. (DUB.), F.G.S., *Assistant
 Superintendent, Geological Survey of India.* (With
 Plates 28, 29 and 29a.)

MY visit to the Yenangyat Oilfield took place in March and April 1908. Since the field has already been mapped by Grimes,¹ as far as the northern limits of Blocks 1 and 2, this paper will deal chiefly with the portion of the field which lies north of these blocks.

As far north as Block 134, the Yenangyat Hills rise sharply from the plain, forming a steep scarp along their eastern flank. To the north of this block, the hills sink gradually and the surrounding country rises to meet them, so that the range becomes indistinct and eventually dies out. The whole area is waterless, uninhabited, and covered with a thin jungle.

The Pegu series, or as it has been termed by Grimes, the Miocene outcrop, extends as far north as Thangyi Daung (lat. $21^{\circ} 22' 40''$ N. ; long. $94^{\circ} 43'$

Pegu Beds. 21° E.), where its topmost bed, the White Sand, can be seen exposed on the anticlinal crest in stream-beds to the north of the hill, and running from thence southwards on both sides of the hill, to form the western and eastern boundaries of the outcrop. This bed, the brilliant colour of which is due to the presence of kaolin, being considerably softer than the rocks above and below, is usually exposed in deep stream-beds coincident with the strike of the rocks, and attains a considerable thickness in the northern part of the field, being overlain, as at Yenangyaung and Singu, by a Red Earth bed, which changes frequently to a red conglomerate with white quartzite pebbles.

South of Yenangyat village, specimens of *Cyrena kodaungensis* Noetl., and a species of *Melania* have been collected from this bed by Mr. Sethu Rama Rao, and in the north of the field I have found in it abundant vertebrate remains, chiefly crocodilian.

The exact similarity of the White Sand bed, and also of the red bed above it, to those of Yenangyaung shows that they are of the same horizon, and we may therefore regard the White Sand as the topmost bed of the Pegu series.

¹ *Mem., Geol. Surv. Ind.*, XXVII, p. 30.

The White Sand bed in the northern part of Yenangyat, is underlain by a series of beds between three and four hundred feet thick, to which no corresponding types are found at Yenangyaung. These beds are a series of current-bedded buff sandstones with ferruginous conglomeratic earthy bands, and are characterised by a great abundance of silicified wood, as well as of selenite; this zone is more or less fluviatile, and is developed all along the western side of the anticline: on the eastern boundary, it can be traced from Thangyi Daung to Block 134, but is missing south of this block, as well as a large and varying thickness of beds beneath it, the greatest thickness of beds being absent at Yenangyat village, where, according to Grimes, a thickness of only 500 ft. of Pegu beds is found east of the crest.

While this fluviatile zone of beds containing both fossil wood and selenite is missing south of Block 134, isolated patches of the red bed and White Sand which overlie it, are found at several localities along the eastern boundary as far south as Block 60. To the south of this block there is no trace of either red bed, White Sand, or of the underlying fluviatile zone.

The eastern boundary of the Pegu series is therefore a very peculiar one, and will be discussed later. With regard to the beds underlying the fluviatile zone above described, it may be remarked that the upper part is poor in fossils and more or less estuarine, while the lower zones near the crest are of a marine type and yield a rich fauna. The Pegu series in this field may be divided as follows:—

Zone 1.—White Sand bed from 10 ft. to 50 ft. thick.

Zone 2.—Fluviatile zone with fossil wood and selenite; thickness 300—400 ft.

Zone 3.—Estuarine beds about 1,600 ft. in thickness, passing gradually into

Zone 4.—Marine beds of shale and sandstone with numerous fossil bands.

In zone 3 both marine fossils and fossil wood have been found, the fossil-bed (containing specimens of *Palanus tintinnabulum* and *Cstrea*) lying above the bed containing silicified wood. This latter bed was found in Block 46 at a horizon some 1,600 ft. below the White Sand and contained, besides fossil wood, a large species of *Ostrea* and some vertebrate remains, chiefly crocodilian.

Selenite is abundant in the zone, the thickness of which is about 1,600 ft. The zone shows pale clayey layers interstratified with somewhat current-bedded sandstones, with frequent ochre-stained bands.

Zone 4 shows well bedded sandstones and shales with numerous fossil-beds, the fauna of which has already been worked out by Noetling. The visible thickness of this zone varies, of course, with the rise and fall of the anticlinal crest, since the bottom is nowhere seen.

The red bed and White Sand are clearly on the same horizon as those of Singu. In the Singu field perhaps the most easily recognisable fossil-bed is that of *Dendrophyllia macroriana* (Rec. Geol. Sur. Ind., Vol. XXXVI, p. 147), it is about one foot in thickness, and is a reddish limestone band crowded with this coral, and containing few other species. This bed is close to the crest at Singu, and has been traced round the field by Mr. Sethu Rama Rau. It is very persistent, forming a continuous outcrop all round the crest, and lying very close to it. The same geologist has traced it in the Yenangyat field as far north as Block 15. Its depth here below the White Sand was calculated to be about 2,300 ft.

This corresponds very well with its horizon in the Singu field, but owing to the rise of the anticline, it is at a much greater distance from the crest in the Yenangyat field. The occurrence of this bed in both fields confirms the belief that the beds exposed at the crest at Yenangyat are of a lower horizon than those exposed at Moksoma Kon in the Singu area, and the fact that the former have been regarded as Yenangyaungian by Noetling, while the latter have been mapped as Promeian, shows that Dr. Noetling's division of the Pegu beds into Yenangyaungian and Promeian is perhaps of somewhat local value.

The upper beds of the Pegu series at Singu are of a shallow marine type, in contrast to the fluvial and estuarine characters of zones 2 and 3 in the north of the Yenangyat field.

The Irrawaddy Sandstone beds of the area do not call for any special description, as they are very similar to those of other fields. It is perhaps worth noting that Mr. Sethu Rama Rau has found in Block 28 a ferruginous bed just above the Red Earth and White Sand beds, containing fossil vertebrate remains. He believes this bed to correspond to that on the east of the Pegu boundary at Singu, described by Dr. Noetling (*Pal. Ind., New Ser.*, Vol. I, pt. 3, p. 31). He observes also that the fossil wood found near this horizon is calcified, while that of the red bed below it is silicified. Calcified fossil wood has also been found in the same horizon in the Irrawaddy series near the eastern and western boundaries of the Pegu outcrop in the northern part of the field.

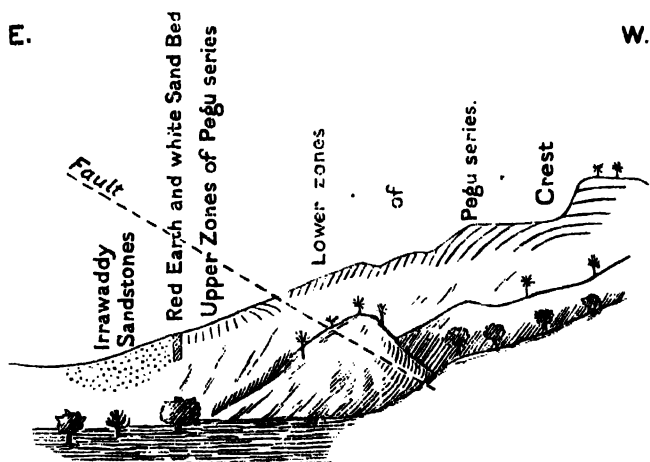
Allusion has already been made to the missing Pegu beds along the eastern boundary at Yenangyat.

The eastern boundary. The question has been discussed by Grimes (*op. cit.*) who decides in favour of unconformity. The unconformity is difficult to explain. The absence of the Red Earth bed, the White Sand, of zone 2, of part at least of zone 3, along the greater portion of the eastern boundary, and of the whole of zones 1, 2, and 3 at Yenangyat village, shows that this unconformity is a very considerable one, 2,500 ft. of strata being absent according to Grimes. It is surely strange that no trace of such an unconformity should be found on the western boundary, either in missing beds or in marked difference of dip: yet it is conceivably possible that this may be the case.

Another objection is that the unconformity, if unconformity it be, lies underneath the White Sand horizon in certain localities in the north of the field (where, as has already been pointed out, portions of the red bed and White Sand are found between Blocks 134 and 60, with missing beds below). At Yenangyat village, however, and from thence both southwards to the end of the Yenangyat field and to the north as far as Block 60, the White Sand itself is missing; hence the unconformity in the greater portion of the field lies above the White Sand, and below it in localities in the north. A third objection lies in the fact that the boundary beds are broken, sometimes contorted, and dip irregularly. They are a mixed accumulation of Irrawaddy rock and broken Pegu strata, filled with selenite of apparently secondary origin. Their condition strongly suggested faulting to me.

A fourth objection is that nowhere have I observed signs of erosion, such as water worn boulders, or pebble beds or other evidence suggesting unconformity along the eastern boundary. Some bed representing an old soil or beach might conceivably mark a line of great unconformity. Grimes, in discussing the question, says:—"That it is not faulted is, I think, evident from the very steep, almost vertical, dip of both series, so that if the difference in thickness of the Miocene beds were due to faulting, the throw of the fault must be very great, and so much so as to be out of the question." This objection of Grimes is certainly valid against the supposition of a down throwing fault with a steep or vertical hade, but not against a thrust-fault with a moderate or considerable hade to the west. If there be a thrust-fault here with a hade to the west we might expect to find beds bent round so as to dip west along the plane of hade. Such beds are seen in a section along the cart-road to the Burma Oil Company's bungalow on Block 134. The section is given

below. It will be seen that in this section the line of possible fault should be placed a little to the west of the Pegu boundary. Elsewhere it coincides with the boundary.



In this section the Red Earth bed, the White Sand, and some of zone 2 are exposed on the east, the dip being somewhat irregular near the fault. At the fault the beds are contorted, and there is an exposure, showing them dipping gently west. West of the fault, we find the normal easterly dip, until the crest is reached.

Strata dipping west can also be observed in Block 60, where the section is rather similar, but the fault is on the boundary.

Although the beds near the boundary dip steeply and almost vertically (except on the actual line of fault, where they can be seen occasionally to dip gently west), the beds near the anticlinal crest and east of it, dip at angles usually less than 60° to the east. There is a somewhat sharp transition from the gentle dips to the steep, which from Block 9 to Block C can be traced as a sharp fold. Sections of this fold are well exposed on the footpath to No. 7 tank, Burma Oil Company and also close to Ayadaw village. A great objection to the explanation above given is that it seems unlikely that a thrust-fault should occur in strata so little contorted or disturbed as those of Yenangyat. Local unconformity between the two series is found at Yedwet and elsewhere; and the anticlines of Yenangyaung and Yedwet were evidently formed by very gentle forces. It may, therefore, seem improbable that a

thrust-fault should occur in this area.' I wish to leave the question undecided, and although it has been shown that there are some difficulties in accepting Grimes' explanation, I should wish the alternative given above to be regarded merely as a tentative suggestion, which can be decided by some future geologist better qualified than myself to deal with the subject.

The relations of the surface and underground crests of this field have been discussed by Pascoe (*Rec. Geol.*

The crest.

Sur. Ind., Vol. XXXIV, p. 253), and it will

be sufficient to describe the direction and rise and fall of the crest in the north of the field.

From Block 134 northwards, its direction is 23° W. of N., and it is sinking rapidly, the Pegu series disappearing under Irrawaddy rocks at Thangyi Daung. The anticlinal structure is seen in Irrawaddy strata in sections on the Pauk-Pakokku road, where the crest crosses near the 27th milestone. Southwards from Block 134 to Block 50, the direction is 20° W. of N. In the Ye-ga block (Block 48) immediately south of Block 50 the crest suddenly changes its direction to S.—N., and in consequence of this the strata near the crest on the western side have become squeezed up, the dips near the crest being much steeper than those taken from strata 1,000 ft. west of it. This change in strike is indicated in Pl. 29.

In Block 123, the crest is rising to the south at a slope of less than 2° according to observations taken with prismatic compass and Abney level. It continues to rise as least as far south as Block 67. Grimes speaks of a crest-maximum in this block, on the Sabe-Ledaing cart-road. I have found no evidence to corroborate this. The Pegu outcrop gradually increases in width to the south. The dips taken in the blocks south of 67 did not suggest that the anticline was sinking southwards. It would however be necessary, I think, to decide this point by mapping recognisable beds by means of large-scale maps, and the largest scale available being on a scale of 1 inch = 1 mile, I was unable to decide the question.

The country to the north of Block 134 may be condemned, since the crest sinks too rapidly. From Block

Prospects of oil.

123 southwards the country seems worth testing; the blocks will probably increase in richness to the south at least as far as Block 67, owing to the rise of the anticline.

ON SOME IRON ORES OF CHANDA, CENTRAL PROVINCES.

BY P. N. DATTA, B.SC., *Assistant Superintendent,
Geological Survey of India.*

IN the north-eastern quarter of the district of Chanda, Central Provinces, surveyed during the season 1907-08, iron-ores were found in three localities, viz., (1) Lohara, (2) Asola, and (3) Dewalgaon.

(1) Lohara ($20^{\circ} 24'$, $79^{\circ} 46' 30''$).—The Lohara ore (specimen K. 254) was reported on by the late Mr. Hughes of this Department as long ago as 1873. He refers to it as a compact crystalline hæmatite or specular iron ore with some magnetic oxide. Although he describes the iron-mass at Lohara as striking, forming a "hill fully $\frac{3}{8}$ th of a mile in length, 200 yards in breadth and 100 to 120 feet in height," he was not able at the time to follow the lode southwards, though he thought that the length of the lode might exceed several miles.¹ The ground was further explored during the last season with the following result:—The lode as mentioned by Mr. Hughes forms a hill. The northern extremity of this hill, where the ore is first found well exposed on coming from the northern direction, lies about $\frac{1}{2}$ mile south of the little hamlet of Lohara, the strike of the hill—which is also that of the lode—being in a north-east by east to south-west by west direction. The hill as one follows it south-westwards loses in height until at about $1\frac{1}{2}$ miles south-west of Lohara it becomes quite low, being thenceforward further traceable only as a very low ridge. Southwards it passes through Aliwahi ($20^{\circ} 22' 30''$, $79^{\circ} 45'$) and, gaining somewhat in height $\frac{1}{2}$ mile further south, finally disappears about a mile south of the village. The iron-bearing rock band either dies out here or is concealed by alluvium; the former contingency is the more probable one, for close to

¹ *Rec. G. S. I.*, VI, p. 77.

its southern visible extremity a granitoid gneiss is seen to crop out.

The rock of the band, as seen at this southern extremity, or by the village of Aliwahi, or about a mile east by north of it, is a hæmatite-quartz-rock, somewhat laminated or foliated—the quartz and hæmatite making up the rock—; but the proportion of silica is so large in these localities as to render it valueless as an ore. So although the actual length of the lode may be slightly greater than is indicated in the estimate furnished by Mr. Hughes in his report, his expectation that it might prove several miles long has unfortunately not been fulfilled, though, as it is, the quantity of ore available must be very large. According to an analysis published in the *Colliery Guardian*, the chemical composition of the ore is as follows :—

Iron, metallic	69·208
Oxygen, in combination	29·376
Manganese sesquioxide	·090
Silica	·823
Alumina	·432
Lime	·054
Magnesia	trace.
Sulphur	·012
Phosphorus	·005

100·000 ¹

(2) Asola (20° 13' 30", 79° 52').²—Asola is a little hamlet 2 miles south-east of Gunjewai. The ore, consisting of hæmatite, occurs on the northern edge of a low hill striking north-west—south-east,

¹ *Colliery Guardian*, September 13, 1873.

² Samples from this and the succeeding locality (Dewalgaon) consisted of chips, which were broken off from the parent-mass, at intervals, all along the length of the exposures. All the fragments of the ore thus collected were handed over to the Curator of the Geological Laboratory for assay; for the samples collected were not large (it was difficult in places to break off more than a chip or so, with the ordinary hammer, owing to the hardness of the rock), and no coning and quartering had been attempted in the field. The average weight of the samples was probably about 30 lbs. from each locality. From each of the fragments of rock one or two pieces (according as the specimen was small or large) were chipped off; these chips were then coned and quartered, and the portion for analysis thus selected.

which is also the strike of the lode, its dip being 35° to 40° to the north-east. The lode lies about 1 mile north-west of Asola and $1\frac{1}{2}$ miles south by east of Gunjewai. Mr. Hughes in his report on the Wardha Valley Coalfield simply refers to it as the Gunjewai lode, giving however no details.¹ As Gunjewai, though hitherto a large village, is now doomed to insignificance or disappearance on account of the great irrigation tank at present in execution at Asola which will thus become henceforth well known, I have indicated the lode as the Asola lode.

The lode is traceable on the surface for about 400 yards, with an average thickness of 30 to 40 feet.

Analysed at the Geological Survey Laboratory (Specimen K. 253) the percentage of metallic iron was found to be 65.99 and of silica 3.89. A complete analysis not having been made, it is not known what minor constituents might be present in the ore.

(3) Dewalgaon ($20^{\circ} 24'$, $80^{\circ} 1' 30''$).—Half a mile south by east of Dewalgaon is a bare bluish-black crag, formed of quartz with hæmatite. The proportion of iron in the rock as broken off from this crag is so small that it cannot be regarded as an ore.

This proportion, however, evidently varies, and this variation must be fairly rapid in places; for pieces of what is a valuable iron ore, found buried beneath the soil, the result no doubt of weathering, are now dug out (and have been so for many years now, so far as I could gather) by men and women, from the southern foot of the crag, to be smelted.

About the village of Dewalgaon itself, two lodes of hæmatite were discovered, one being about 100 yards north-west and the other about 400 yards south by east of the village. These may be conveniently referred to as the (i) North-western, and (ii) Southern lodes.

(i) North-western lode.—The ore is a hæmatite and so far as it is exposed, the lode is 255 feet long, with a thickness of 4' 6". But, for a length of 30 feet (out of the 255 feet), the thickness increases to 9' 6". Owing however to alluvium and soil of cultivation it is impossible, without actual excavation, to say whether the lode extends further in length and breadth. The dip is west by south at 50° .

¹ *Mem. G. S. I.*, XIII, pt. I, p. 110.

Partial analysis in the Geological Survey Laboratory gave 61·2 and 11·04 as the percentages of metallic iron and silica respectively.

(ii) Southern lode.—The visible northern extremity of the lode, also a hæmatite (K. 256), is about 400 yards south by west of the village and is traceable south-eastwards for about 300 yards, with an average width of 20 feet. Beyond this point, *i.e.*, towards the south, the rock becomes less ferriferous, as seen on the crag already alluded to. The variation in the percentage of iron in the rock must be somewhat capricious, for at the southern foot of the crag an ore of a fairly good quality has been and^o is at the present day dug out from underneath the soil, indicating that the outcrop, though it may be unpromising at one spot, may yet yield a fair ore, even in its immediate neighbourhood. A little further south-east from the foot of the crag, the rock becomes a pure quartz, free from association with iron.

Chemical analysis in the Geological Survey Laboratory gave 67·76 per cent. of metallic iron and 1·50 per cent. of silica.

Whether the north-west lode is continuous with the southern one, it is not possible to be perfectly certain, without actual excavation. The village itself shows nothing but laterite; but as this laterite is very like that into which a portion of the north-west lode was clearly found to have been converted, it is very probable that the village stands on a lode, being the connecting middle portion between the north-west and south lodes.

The following statement as to the deposits of iron ore of Bissí, Pipalgaon and Ratnapur as given by Mr. Hughes in his paper on the Iron Deposits of Chanda may be added here, as this will make a fairly complete statement as to the occurrences of iron ores in the district, so far as yet known:—

“BISSÍ.—Long. 79° 28' East, and Lat. 20° 39' North.—The ore occurs in a lode about a mile directly east of the village and contains hæmatite and magnetic oxide of iron.”

“PIPALGAON.—Long. 79° 34' East, Lat. 20° 32' North.—An excessively fine mass of red hæmatite, resembling that which occurs at Lohárá, and having probably the same composition, is to be seen about three-quarters of a mile east of Pipalgaon. The strike of the lode is west-north-west, east-south-east.”

“**RATNÁPÚR.**—Long. 79° 37' East, and Lat. 20° 23' North.—A very rich lode of brown iron ore, forms a terrace on the north side of the small range of hills facing Alísúr. The width of the lode in places is 40 and 50 feet.”¹

Pipalgun ore, as analysed by Mr. Noss²:—

Protoxide of iron	63·0	
Peroxide of iron	31·5	
Lime	·5	
Magnesia	trace.	} not estimated.
Phosphorus	do.	
Sulphur	do.	
Silica	4·5	
Water traces and loss	·5	
		—————
		100·0

metallic iron 71·05.

Ratnapur ore:—

(1) Analysis by Mr. Ness—

Metallic iron	49·7
Insoluble	26·0

(2) Analysis by Mr. Tween—

(a) Metallic iron	50·5
Insoluble	22·8
(b) Metallic iron	52·0

(3) Analysis of laterite near Ratnapur—

Metallic iron	25·7
-------------------------	------

Yenak Hill.—Conglomeratic bands in this hill contain pebbles of hæmatite, with 56·3 to 68·5 per cent. of metallic iron, and with mere traces of phosphorus and no manganese.³

¹ *Rec. G. S. I.*, VI, p. 78.

² *Mem. G. S. I.*, XIII, pt. 1, p. 111.

³ *Mem. G. S. I.*, XIII, pt. 1, p. 111.

THE GEOLOGY OF THE ADEN HINTERLAND. BY CAPTAIN
R. E. LLOYD, M.B., D.SC., I.M.S., *late Surgeon-
Naturalist, Marine Survey of India.* (With Plates
30 to 33.)

THESE notes were made after a three weeks' tour in the Aden Hinterland, which was taken at the instigation of the Political Resident of Aden, Major-General H. M. Mason, during the early part of 1906. The opportunity for making this tour arose unexpectedly, so that I was unacquainted at the time with the previous work on the geology of the Aden district. My attention has since been drawn to two papers on the geology of Aden and the neighbourhood. Mallet¹ examined the crater of Aden, and the desert country to the north as far as the foot-hills, with reference to the advisability of sinking artesian wells in the district. He writes: "from Majhafa, I marched nearly due north to the foot of the hills, but on account of the disturbed state of the country I was unable to enter them." He was, however, able to examine the outlying hills and described in them a thick sedimentary series of limestone and superimposed sandstone. The limestone contained fossils, which were referred to by Dr. Stoliczka, in the following words: "The few fossils appear to resemble most upper jurassic forms, though the same genera also occur in lower cretaceous beds."

McMahon² has described the petrological characters of lavas taken from the Aden crater, about which nothing is here recorded.

The line of country examined by the present writer extends due north, from Aden on the coast to the town of Dala, ninety miles inland. The southern half of this is a flat desert devoid of outcropping rocks; it was described by Mallet.

At the time of my visit it was possible to travel forty miles through the hills to Dala: although to wander from the road to any extent was still considered inadvisable. The road enters the foot-hills at the village of Nobat Dakim and gradually ascends to Dala, which lies among hills six or seven thousand feet in altitude.

¹ *Mem., Geol. Surv. India*, VII, p. 257, (1871).

² *Rec., Geol. Surv. India*, XVI, p. 145, (1883).

A short description of the geology of the hills seen on the road, with a somewhat fuller description of the rocks immediately round Dala, form the subject of these notes. The rocks may be divided at once into two divisions, a sedimentary series of limestones and sandstone (previously described by Mallet), and a more recent igneous series, which, in this part of the country, is represented in a much wider area than the sedimentary rocks. The igneous rocks, comprising more than nine-tenths of the area examined, will be described first.

For descriptive purposes they may be separated into three divisions :—

- (1) The horizontally bedded lavas.
- (2) The beds of volcanic ashes.
- (3) The massive lava.

1.—The Bedded Lavas.

Rocks of the first division are best seen in the immediate neighbourhood of Dala. The town of Dala is situated at the southern end of an extensive plain, which is about 10 miles in length from north to south, and 3 or 4 miles in breadth at its southern end, but which widens out considerably towards the north. This plain slopes gently to the north and is surrounded, except at the north-west corner, by a rampart of hills, rising two or three thousand feet above it. On the west the plain is bounded by a group of hills known as Jabal Jihaf. This range does not join the northern boundary of the plain, being separated therefrom by a wide gap, through which the drainage of the whole area leaves by the Kataba stream to join the Wadi Tiban (see map and Plate 31). The northern boundary is a long escarpment which marks the southern limit of the Mares and Shaibi districts. The eastern end of this escarpment curves in a southerly direction to join a range called Jabal Harir, which forms the eastern boundary of the plain. The Dala hills, on which the town itself is situated, mark the southern limit of the plain. These hills are very uniform in structure, consisting of layers of compact black lava, alternating with layers of amygdaloidal lava.

The latter is usually in a soft crumbly condition and weathers away readily, leaving the layers of compact lava standing out in relief.

From the alternation of these layers a very distinct appearance of stratification results, which is best seen on the northern aspect of the hills, where they face the plain (Plate 30).

Immediately around Dala these lava flows dip towards the south at angles of 20° to 30° . To the west, where the Dala hills are continuous with the Jabal Jihaf range, the layers dip to the south-south-west and south-west at similar angles. Further to the north in the direction of Sana and beneath the northern end of the Jabal Jihaf are low hills of a similar structure, the component layers of which, although somewhat irregular as regards plane of bedding, show a general tendency to dip to the west. In considering these rocks as a whole as regards direction of dip, it will be noticed that this is along lines arranged radially away from an imaginary point situated near the middle of Dala plain.

Regarding the direction of dip in the escarpments of the Mares, Shaibi and Harir districts, nothing can be said from personal observation, as it was impossible to visit them: but to an observer standing in the middle of Dala plain, the appearance of these escarpments is that of a series of horizontally disposed strata (Plate 31). A similar horizontal appearance is offered by the Dala hills from the same point of view. These latter hills, as above mentioned, dip to the south and south-west away from the centre of the plain, and it is probable that the strata composing the escarpments of Mares, Shaibi and Harir also dip away from the centre of the plain in a north and north-easterly direction as they would if deposited from a centre of volcanic activity situated near the middle of Dala plain.

As previously mentioned, the stratified appearance of all these rocks is due to the alternation of compact lava with soft amygdaloidal rock. The compact lava, which is the predominant rock of the neighbourhood, is tough and black, with porphyritic crystals of a translucent green mineral. Mr. H. Walker of the Geological Survey of India has kindly given me the following description of it. "A porphyritic dolerite of medium grain. Olivine occurs in large idiomorphic crystals, and augite occurs in two generations; the older as a large porphyritic one and the younger as a fine granular generation. The rock is fresh." The layers of the rock vary in thickness from one to twenty feet. These layers or sheets of lava extend laterally over a considerable distance, as much as half a mile or more in some cases, though many are of less extent.

They terminate laterally by thinning down and passing into the rotten amygdaloidal rock. This latter appears to be of similar composition to the compact lava, but contains innumerable globules of a white calcareous mineral, which are assumed to be steam vesicles filled by infiltration.

Besides the bedded lava there occurs a compact fine-grained trap devoid of porphyritic crystals; this is disposed in vertical dykes intrusive into the other rocks. These dykes are often about 3 or 4 feet in thickness and in the neighbourhood of Dala lie approximately east and west.

Bedded lava with intrusive dykes is the prevailing rock in the immediate neighbourhood of Dala. The several isolated hills on the Dala plain such as Jabal Shahad, Jabal Asoda are of this composition; and judging from the appearance they present in the distance, the escarpments of Mares, Shaibi and Harir are of a similar nature. In regard to their origin there seems little doubt that they were formed sub-aerially by successive lava flows, the central part in the thickness of each flow forming the compact layer, above and below which the lava is amygdaloidal. The regularity with which these layers dip away from a point about the middle of Dala plain, suggests the view that the successive lava flows issued from a crater whose axis occupied this position. And further it seems that except for extensive erosion and slight mineral changes, the rocks have not been much altered since the date of their deposition.

2.—The Beds of Volcanic Ashes.

These occur locally to the south and west of Dala; they are to be found on the road from Dala to Dabiyat about four miles from the latter place, also on Jabal Jihaf, both close to the Dala plain and in the neighbourhood of Karna, where the newly made Al Haki road has been cut through them. These rocks catch the eye at once, owing to the brightness and variety of their colours: light green, pink, red, yellow, buff, chalk white and other tints. Although differing greatly in colour, these various rocks resemble one another in being finely stratified. Their smallest particles usually show a horizontal arrangement. These beds are never disposed horizontally, but dip at pronounced angles, usually less than 30°.

In Jabal Jihaf they dip to the south-west, but towards Dabiyat they can be seen dipping towards any point of the compass, and occasionally beds of one colour lie unconformably over beds of another colour. The ash beds of Jabal Jihaf show an interesting feature in the form of narrow layers of light brown siliceous rock. These layers are about 6 inches in thickness and lie a few feet apart. They show well marked foliation, and conform in position to the beds of ashes among which they lie.

These brightly coloured rocks were probably formed from volcanic ashes, in part air borne perhaps, but chiefly mixed with water in the form of volcanic alluvium or aqueous lava, the siliceous bands being deposited in the form of siliceous sinter from hot springs, during the formation of the ash beds. They seem to have been little disturbed since the time of their deposition.

3.—The Massive Lava.

These rocks being situated above the others have an important influence on the appearance of the country. They form plateaux and pinnacle-rocks which give a characteristic appearance to the landscape.

Good examples of plateaux are seen in Dabiyat and Mafari; these are flat-topped hills of considerable area situated to the south of Dala. That of Dabiyat is about $1\frac{1}{2}$ square miles in area. They are bounded on all sides by perpendicular cliffs about 200 feet in height, composed of compact grey dolerite, which thus forms a flat cap to the hill, resisting erosion and giving to the hill its characteristic shape. Both plateaux are about 6,000 feet above sea level. They are only six miles apart and must have resulted from one great sheet of lava of many miles extent.

Many of the pointed hills in the Jabal Jihaf group are also capped with 100 feet or more of this same lava.

Besides occurring in the form of plateaux and points capping the summits of the higher hills, the massive lava occurs not uncommonly in the form of pinnacles which appear to be eroded necks of lava occupying the lesser volcanic vents. A good example of such a pinnacle rock is seen about a quarter of a mile to the north of the Dabiyat plateau (Plate 32). Here the coloured ash-beds are to be seen sloping away from the central column of lava.

The elevated position of these plateaux and pinnacles show that the massive lava is of a later date than the rest of the volcanic series. Probably at this later date a great outflow of lava occurred, filling up the numerous smaller vents and forming an extensive sheet over the whole district. This probably brought the active volcanic period to a close and there has been little change since, except for the extensive erosion required to bring the hills to their present shape.

Before concluding the description of the igneous series the commoner infiltrating minerals, present in these rocks, must be mentioned. Calcite in various forms is the most common. Nests of pure calcite crystals are frequently met with. The white mineral which occurs throughout the amygdaloidal lava has a calcareous basis, though it is not entirely soluble in strong acid. Quartz, both in crystalline and milky chalcedonic form, occurs more rarely. Hematite is very commonly diffused through the rocks, but is rarely met with in any quantities in a pure form.

The Sedimentary Rocks.

Sedimentary rocks were met with at two places: in the valley of the Bilih between Nobat Dakim and Almulah and to the east of Sulaik in the valley of a stream which flows down from the village of Masra. At both places the rocks are of the same nature, consisting of a fossiliferous limestone with a superimposed sandstone of considerable thickness, both altered by contact with the later igneous series. The sedimentary rocks are best displayed on the south side of the Masra valley, two miles from Sulaik Fort. Here the limestone is highly fossiliferous and the sandstone is seen resting upon it.

The limestone is composed of compact layers of stone which vary in thickness from 2 or 3 inches to as many feet. These layers alternate with softer shaley bands which weather away, leaving the harder rock in relief. The surface colour of the rock is light grey. In outward appearance it presents, as a whole, a close resemblance to the lower Lias as seen in the sea cliffs of Dorsetshire. The resemblance does not extend to the internal structure, however. This rock is very tough and breaks often with a semi-conchoidal fracture. A fresh fracture shows a dark, almost black, surface, with some crystalline sparkle. At the place where it was examined the

limestone dips to the west at an angle of 25° , forming part of an open anticline, which, owing to restrictions, was not fully explored. Not more than 300 feet of the limestone was seen, for its lowest part was lost beneath the river bed. The change from the limestone to the sandstone is rather sudden. Towards the upper part of the limestone the shaley beds predominate, but layers of compact limestone occur only 15 feet below the typical sandstone.

Fossils abound in this limestone. Good specimens however are difficult to obtain, for on breaking the rock the fractures usually pass through the fossils. From the weathered surface several fossils were obtained; they include three species of ammonites, belemnites of more than one species, the joints of *Pentacrinus*, and molluscs of the genera *Trigonia*, *Pinna*, *Pecten*, and a gastropod.

The *Trigonia* closely resembles *T. costata*. These fossils are of Upper Jurassic age and are described by Mr. G. H. Tipper on pages 336—340.

The thickness of the sandstone in the Masra valley must be at least 2,000 feet. It shows a well marked plane of bedding which, like the limestone, dips to the west at an angle of about 25° . The colour of the fresh surface is generally a light buff, in places it is almost white with a pinkish tinge, in other places it shows red mottling from iron. The individual sand grains are rather coarse and in many places the rock could be described as a coarse grit. Throughout, the sandstone is very compact in structure, the individual grains cohering very firmly, and locally this peculiarity is so marked that the rock becomes a quartzite. The structure known as "false bedding," characteristic of shallow water deposition, is frequently seen. Towards the upper part of the sandstone, beds of small pebbles occur; these are generally of pink or white semi-translucent quartz and are obviously water-worn. No signs of organic remains were met with in this sandstone.

The highest part of the formation is seen at the western end of the valley, about half a mile from Sulaik Fort. Here some interesting features appear. Interstratified with the normal sandstone are beds composed largely of volcanic fragments, pebbles of lava, and coarse ash, intermingled with quartz grains; all clearly of aqueous deposition. Examination of this part of the series leads to the assumption that the volcanic period gradually succeeded the deposition of the sandstone without the intervention of any great space of time.

The sedimentaries in the valley of the Bilih are of the same type as those of Masra, but it happened that they were less accessible for examination. The limestone of the Bilih is more massive and less shaly than the other, the fossils in it are fewer, while trap dykes abound. It is tough, black and crystalline. The sedimentaries are widely represented to the east and west of the line of country examined.

PETROLOGICAL NOTES ON THE ROCKS COLLECTED BY
CAPTAIN R. E. LLOYD, NEAR ADEN. BY E. W.
VREDENBURG, A.R.S.M., A.R.C.S., F.G.S., *Assistant
Superintendent, Geological Survey of India.*
(With Plate 34.)

Contents.

	PAGE.
INTRODUCTION	322
JURASSIC ROCKS	323
PROBABLE REPRESENTATIVES OF THE DECCAN TRAP	323
THE DALA COLLECTION	324
Acid Rocks	325
<i>Rhyolitic lavas</i>	325
<i>Rhyolitic ash-beds</i>	326
<i>Rhyolite-breccias</i>	326
Doubtful Andesites	327
Basic Rocks	328
<i>Dolerites</i>	328
<i>Ordinary basalts.</i> —Basalts without olivine resem- bling the Deccan Trap ; olivine basalts	329
<i>Exceptional basalts.</i> —Augite rock with vacuoles occupied by felspar and epidote ; olivine- porphyry	330
<i>Minerals from geodes in the basalts</i>	332
Sandstones	332
THE SALEIK COLLECTION	333
Acid Rocks	333
Basic Rocks	334
Sandstones	335
ROCKS FROM THE ADEN VOLCANO	335
MINERALS OF COMMERCIAL VALUE	335

Introduction.

From the interesting notes supplied by Captain Lloyd on the subject of the geology of the neighbourhood of Aden, it appears evident that, apart from the products of quaternary eruptions constituting the Aden volcano, the rocks examined belong at least to two geological periods. There is an older series of sedimentary rocks shown by their fossil contents to be of Jurassic age, and a newer series of volcanic rocks associated with aqueous sediments. The exact manner in which this association occurs is not quite clear from the descriptions available, but it is probable that, at least in some cases, the volcanic rocks represent true contemporaneous intercalations, probably of the same age as the interbedded sedimentary and volcanic rocks of Upper Cretaceous age which occupy such large areas in Balúchistán and Persia, where they constitute the local representatives of the Deccan trap of the Indian Peninsula.

Two points remain slightly obscure from the available descriptions; these are the mutual relations of the bulk of the volcanic rocks to the overlying formation described as "the massive lava," and also the exact age of the intrusive dykes that traverse the bulk of the volcanic formation but are not mentioned in connection with the "massive lava."

It seems, from the published description, that the "massive lava" is almost horizontally bedded, very much after the manner of the Deccan trap in the plateau-forming accumulations of the Deccan and Malwa in the Indian Peninsula. The quaquaversal dip of the volcanic beds away from the Dala plain is regarded as an original feature, indicating the position of a former centre of volcanic activity from which all the beds sloped away in radial direction. If this be really the case, the unconformity of the "massive lava" need not imply any great difference in age. It is very doubtful, however, whether this interpretation be correct, for, so far as can be gathered from the descriptions, the sedimentary intercalations at Saleik share the dip of the volcanic rocks; and this would suffice to show that the inclination of the beds cannot be an original feature, and that the structure of the Dala plain and its surrounding scarped rim is that of a dome-shaped anticline of tectonic origin, whose structure has been acquired long after the accumulation of the volcanic series, and which is analogous in disposition and origin to similar features observed in certain parts of

Western Sind and of Kachh. That being so, the undisturbed "massive lava" might be of much later date, and might be contemporaneous with the volcanic system of quaternary age to which belong the Aden volcano and other volcanoes of the south coast of Arabia. Nevertheless, the enormous amount of denudation which it has undergone rather favours the idea that it is a true member of the older volcanic formation, the appearances of unconformity and horizontality being perhaps deceptive.

As regards the intrusive dykes mentioned by Captain Lloyd, it is not possible, from the data available, to make certain whether they belong to the period of activity of the older, probably Upper Cretaceous volcanic rocks, or to a later period, though the descriptions rather suggest a connection with the "massive lava."

The numerous specimens are mostly unaccompanied by stratigraphical indications and do not help therefore to elucidate these uncertain points.

Jurassic Rocks.

The Jurassic rocks represented in the collection are chiefly compact limestones whose colour on the fresh fracture varies from grey to nearly black, and whose exposed surface weathers with a thin somewhat buff-coloured crust, the tint becoming often distinctly ferruginous where certain fossils have weathered in relief. These fossils constitute the chief interest of the specimens, and have been described by Mr. Tipper.

Probable Representatives of the Deccan Trap.

There is a large collection of specimens from the older volcanic series, and although there is a slight uncertainty as to whether some of them may have been obtained from the intrusive dykes or "massive lava" of uncertain age, the bulk of the collection recalls so completely the assemblage of rocks which it is customary to meet with in the Upper Cretaceous volcanic formation of Baluchistán and Persia, that their petrographical facies taken in connection with their evident superposition upon the Jurassic rocks leaves little doubt as to their belonging to the same formation. Rocks of this age are largely represented in the Indian Peninsula by the vast accumulation known as the Deccan trap, a basaltic formation whose chief petrological peculiarity is the scarcity or absence of the mineral olivine.

The bulk of the Upper Cretaceous volcanics outside the Indian Peninsula consists of andesites, though one frequently observes intercalations of basalts quite as basic as those of the Indian Peninsula, and occasionally rhyolites. The extra-peninsular basalts of this period generally contain olivine, and differ thereby from the basalts of the peninsular Deccan trap.

THE DALA COLLECTION.

Most of Captain Lloyd's specimens have been collected near Dala, and they include a very complete assemblage of rocks such as usually characterise the extra-peninsular facies of the Deccan trap.

The Dala collection includes the following types of rocks (the numbers being those under which the specimens are registered in the Geological Museum at Calcutta):—

Rhyolite or devitrified obsidian, 21-153.

Rhyolites, 21-112, 137, 138.

Rhyolitic ash-beds, non-calcareous, 21-110, 111, 113, 114, 115, 116, 134, 135, 142, 143, 144, 145, 146(a), 147.

Rhyolite-breccias, 21-126, 127, 128, 132, 133.

? Altered andesites, 21-120, 121, 129.

Fine-grained dolerites, 21-131, 139.

Ordinary basalt, 21-118.

Augite-basalt, 21-140.

Scoriaceous amygdaloidal basalts, 21-119, 125.

Basalt weathering spheroidally, 21-152.

Olivine-basalt, 21-130.

Basalt, exceptional type with epidote, 21-141.

Olivine-porphry basalts, 21-123, 124.

Substances of the same type as usually occur in the large geodes of the Deccan trap; including agate and quartz, 21-109, 148, 149, 150; chalcedony, 21-151; green jasper, 21-117; red ferruginous jasper, 21-174; red jasper interbanded with chalcedony, 21-136; chert and opal, 21-159-163; calcite, 21-122; calcite stained black with manganese oxide, 21-162.

Sandstones, 21-154-158.

Acid Rocks.

The above list shows that the prevailing types of rock in the Dala collection are either distinctly acid or distinctly basic, the intermediate andesites being doubtfully represented by a small number of rather obscure specimens.

The acid rocks are represented by rhyolitic lavas, rhyolite breccias and ash-beds.

It should be noticed that these rocks never contain any plagioclase felspar, except among foreign fragments in some of the ash-beds. They are therefore true rhyolites, and not pseudo-rhyolites approaching dacites like certain lavas of Gujrat (Pawagarh Hill) and Kathiawar in the Deccan trap outcrop of India.

The proportion of silica in one of these rocks (21-112) determined by Mahadeo Ram, Laboratory Assistant, is 73.54 per cent., which indicates a typical rhyolite, whilst in the pseudo-rhyolites of Pawagarh hill the proportion never reaches 70 per cent. (*Rec. Geol. Surv. Ind.*, Vol. XXXIV. p. 158). Some of the features exhibited by these rocks are sufficiently interesting to deserve special notice.

Rhyolitic lavas.

The specimen numbered 21-112 is a good example of the normal rhyolites. Its specific gravity is 2.47.

The rock, in its unaltered portion, consists of a pale greenish-grey groundmass through which are scattered numerous porphyritic crystals of orthoclase felspar from 1 to 4 mm. in diameter and a few crystals of quartz of about 1 mm. The felspar crystals are opaque-white, the quartz crystals transparent. The rock is altered in places where it is stained red, the colour spreading over the felspar crystals and recalling the appearance of "rosso antico". The proportion of the felspar phenocrysts is almost one-half of the bulk of the rock.

Under the microscope, the base is obscurely cryptocrystalline, profusely strewn with dust-like opaque particles not more than 0.005 mm. in size and with fairly numerous minute crystals of quartz or felspar of about 0.05 to 0.1 mm. in dimension.

The felspar phenocrysts show crystal outline, cleavage cracks, but no twinning. They are occasionally aggregated in glomeroporphyritic groups. The quartz crystals exhibit the corroded outline characteristic of rhyolites. There is sometimes a shallow fringe of secondary growth round the felspars.

The rock numbered 21-138 (Plate 34, fig. 1) is a very fresh-looking, lilac-coloured rhyolite, rather cavernous. It contains porphyritic feldspars of about the same size as in the previously described rock, their proportion as compared to the base being somewhat less. Quartz phenocrysts are somewhat more abundant. Flow-structure is conspicuous both in the hand specimen and microscope slide. The microscopic structure generally closely resembles that of the rock previously described. The feldspars are all orthoclasic, quite fresh, and occasionally twinned. The base is finely crystalline, this being partly the result of secondary devitrification. The outward appearance of the rock differs from that of the previously described rhyolite, the porphyritic aspect being far less evident in consequence of the freshness of the sanidine-feldspars, which have remained transparent instead of showing as opaque white patches.

The rhyolitic ash-beds, which form such a large proportion of the collection from Dala, are fine-grained, often sharply-bedded, rough-fractured to porcellanoid rocks, usually of a fresh bright-green colour. The typical members of this group of rocks are non-calcareous. Owing to their fine texture, the nature of the component grains cannot be clearly made out by means of an ordinary lens. Under the microscope one distinguishes fragments of volcanic quartz, volcanic feldspar, glass and pumice. The rock is non-calcareous. The ash-beds of Pawagarh Hill in the Indian province of Gujrat are very similar, but of a much less vivid colour.

Most of these ash-beds are of a vivid light-green colour (21-110, 114, 115, 116, 146, 147); occasionally they exhibit various tints of red, buff, grey, lilac, or white. The colouring is either uniform or disposed along bands parallel with the stratification. Several specimens are green with red spots, and, in one instance (21-134), it is to be noticed that every one of the green patches represents a fragment of pumice.

The rhyolite-breccias include grey and purplish red rocks whose fragmentary nature is evident in the hand-specimens. When examined under the microscope they are found to consist of fragments of rocks similar to those just described, together with fragments of volcanic glass, pumice, and obsidian.

The specific gravity of these breccias varies from 2.47 (specimen 21-132) to 2.49 (specimen 21-127).

The rhyolitic ash-beds from Dala are not calcareous, but the breccias are often distinctly so (particularly the specimens 21-126, 127, 133), calcite impregnating the fine-grained dust between the larger fragments.

Doubtful Andesites.

Captain Lloyd's collection does not contain any typical andesites, though there are a few specimens that may perhaps be related to this group of rocks. One of the characteristics of the rhyolitic rocks above described is the absence of calcite amongst the decomposition products, except in the case of the breccias, where the calcareous matter may be of foreign origin. There are, however, a few highly felspathic rocks, of low specific gravity in which the abundance of secondary calcite suggests the original presence of a certain proportion of plagioclase feldspar, while there is, at the same time, a complete absence of porphyritic quartz crystals amongst these particular rocks. They are grey to lilac-grey, trachytic-looking, fine-grained rocks, the fracture of which exhibits a peculiar sheen, owing to secondary calcite having crystallised in crystallographic continuity over large areas. Occasionally they are superficially stained red, like some of the rhyolites. When examined under the microscope, they are found to have a minutely crystalline felspathic base, resembling that of some of the fels-rhyolites already described, while the porphyritic crystals are, in one case (21-120), phenocrysts or glomero-porphyrific aggregates of feldspar entirely replaced by calcite, in another case (21-129) dark opaque patches with a crystalline outline recalling that of hornblende. The rock with the altered feldspar phenocrysts has a specific gravity of 2.62, that with the dark pseudomorphs, of 2.44.

Another rock of the same category is that numbered 21-121, which shows a very distinct banded structure. The specimen consists of two portions representing two successive bands: a compact grey-lilac portion, with minute white patches arranged in parallel streaks, and a finely porous portion of brick-red colour. The porous crust must represent the marginal portion of a lava flow. Under the microscope the compact portion shows an imperfectly polarising groundmass with conspicuous flow-structure, rendered semi-opaque by a suffusion of extremely fine iron-ore dust, through which are scattered numerous minute laths of plagioclase, with their longer axis parallel to the direction of flow, and which,

from their small extinction angles, appear to be oligoclase. Their average length is 0.15 to 0.2 mm. There are also some elongated masses of calcite of about 1 mm. in length disposed in linear series along the same direction, probably representing a secondary infilling of elongated cavities. It is these that give a streaky appearance to the hand specimen. The outer finely vesicular portion of the lava has its base rendered almost opaque by the decomposition products to which it owes its red colour. The felspar laths are the same as in the compact portion, but scattered irregularly at all angles, instead of being disposed in parallel manner.

Basic Rocks.

Whilst the group of the andesites is only doubtfully and uncharacteristically represented, that of the basic rocks is richly developed, and includes numerous rocks identical with those of the Deccan trap of the Indian peninsula, together with others of less familiar appearance.

The basic rocks from the Dala region include both fine-grained dolerites and true basalts.

One of the dolerites, that numbered 21-131, is remarkable for its beautiful pleochroic augites of purple colour by transmitted

Dolerites.

light, the crystals of which are distributed in porphyritic fashion amongst the labradorites, although optically intergrown with them. There are also grains of iron ore. The augite grains when in the shape of short prisms average 1 mm. in width, but sometimes they assume elongated shapes when the length frequently reaches 2 or 3 mm. The labradorite prisms often reach a length of 0.7 mm., these larger crystals being accompanied by many others of smaller dimensions. The rock contains cavities sometimes over 5 mm. in diameter, lined with a devitrified glass which is yellowish green by transmitted light, the remainder of the cavity being filled with zeolites and opal and occasionally with quartz.

Another basic rock which, although fine-grained, has elements sufficiently large to be recognised without the aid of a microscope, and which is therefore entitled to rank as a dolerite, is the rock numbered 21-139. It has a "pepper and salt" appearance due to the association of opaque white feldspars (labradorite) and black augites. The average length of the feldspar and augite prisms is

from 0.5 to 0.8 mm. There are no porphyritic crystals. Both the labradorite and augite are colourless in thin section. Ophitic intergrowth of the augite occurs only locally. The augite is fresh, the labradorite altered. Thin sections also reveal the presence of a fair proportion of altered iron ore, and of secondary serpentine, and also some secondary calcite. This dolerite closely resembles many of the dyke-rocks of Deccan trap age that one observes in Balúchistán. Its specific gravity is 2.84.

Ordinary Basalts.—The basalts which seem to constitute a considerable proportion of the scarps surrounding the Dala plain are to a large extent normal representatives of this class of rocks. The specimen numbered 21-119 particularly recalls certain varieties of the Deccan trap of the Indian Peninsula. It is a vesicular purplish black rock with large glomero-porphyrritic aggregates, of about 5 mm. in diameter, of unaltered labradorite and geodes of about the same size

Basalts without olivine resembling the Deccan trap. filled with calcite, zeolite, or “green earth.” Under the microscope the base shows numerous lath-shaped labradorites 0.1 to 0.4 millimetres in length, scattered through an almost opaque matrix. There is no undecomposed augite.

Another rock not unlike some varieties of the Deccan trap is the one numbered 21-140. It is a grey compact rock with stony fracture, of even grain and without conspicuous phenocrysts. Under the microscope it appears to consist principally of augite and labradorite in approximately equal proportions, both occurring in the shape of prisms with an average length of 0.3 to 0.4 mm. There is a fairly large amount of iron ore, and the section appears much stained with a green chlorite-like decomposition product, while there is also a certain amount of secondary calcite. Occasionally one notices a phenocryst of augite about 0.6 mm. in width.

The rock numbered 21-118, a dark grey compact fragment, with rough fracture, non-vesicular, showing numerous porphyritic and glomero-porphyritic labradorites, resembles some of the most basic forms of Deccan trap basalt.

The three rocks above described recall the Deccan trap, owing to the absence of olivine. The rock numbered 21-130 is a black compact basalt constituted by olivine basalt. augite, labradorite, and iron ore, very much in the same manner as the rock just described, only with

smaller elements; the chief point worthy of notice is the occasional presence of small idiomorphic porphyritic crystals of fresh olivine up to 0.4 mm. in diameter. The specific gravity of this rock is 2.97.

Exceptional Basalts.—The next rocks, numbered 21-141 and 21-123, are rather exceptional.

The rock numbered 21-141 resembles at first sight an ordinary vesicular basalt, in which the cavities have been secondarily filled by some white mineral. These approximately spherical geodes are from 1 millimetre to 2 millimetres in diameter, and are profusely scattered through a grey-coloured base too fine-grained to be resolved into its constituent elements by an ordinary lens.

Augite-rock with vacuoles occupied by felspar and epidote.

In addition to the geodes filled with the white mineral there are some vacuoles of about the same size partly coated with transparent prismatic crystals of green epidote. Sometimes this same epidote is associated with the white opaque mineral which completely or nearly completely fills the majority of the globular cavities. When the white crystals do not entirely fill the cavities, they show distinct crystal terminations. The examination of thin sections under the microscope reveals a very abnormal rock. The base is made up of small prismatic crystals of augite averaging 0.1 to 0.2 mm. in dimension, together with a certain proportion of iron ores and a green fibrous serpentinous substance in the interstices between the crystals. The globular cavities are coated with a very thin film about 0.01 mm. thick, consisting of a fibrous serpentinous substance, green by transmitted light, which appears to be a devitrified glass. It is the same substance that fills the interstices between the augite crystals of the base. The white mineral occupying the globular cavities consists of felspar, which must have solidified subsequently to the augites and even after the glass of the base. The matrix is devoid of felspars, just as the geodes are devoid of augite. The fibrous serpentinous substance does not represent reaction rims, for it is observed not only between the felspar and augite, but also amongst the augite crystals, and occasionally occurs also as a lining to empty cavities.

Of the minerals that occupy the cavities, the felspars have crystallised in irregular aggregates without any distinct radial disposition, the epidotes in beautiful radiating aggregates. The average length of the felspar prisms is about 0.1 mm. They occasionally

show twin lamellation, and, judging from the angles of extinction, they appear to be some form of labradorite. Sometimes the cavities contain one of the two minerals; at other times both mineral occur together, in which case one observes that the epidotes have crystallised subsequently to the felspars. Sometimes zeolite has filled a space that had remained vacant subsequently to the formation of both the felspar and epidote.

The specific gravity of this curious rock is 2.96.

The next rock, 21-123 (Plate 34, fig. 2), which might be described as an olivine-porphry, includes the ordinary constituent minerals of basalt, that is olivine, augite, plagioclase and iron ore. The

Olivine-porphry. porphyritic crystals consist almost entirely of olivine, a stray individual of augite being also occasionally observed. The conspicuous olivine crystals are embedded in a black or dark grey stony base too fine-grained to be resolved into its constituent minerals by means of an ordinary lens.

The specific gravity is 3.08.

The porphyritic crystals of olivine constitute about one-third in bulk of the rock. They have the shape of stumpy prisms often with pyramid-like terminations, their commonest dimension being about 2 millimetres, while there are also smaller crystals, and a few larger ones occasionally more than a centimetre in length. The mineral is transparent, of a gum-like appearance and pale yellow colour slightly tinged with green. It is quite colourless in thin sections. It is practically unaltered, but traversed by numerous conchoidal cracks, sometimes lined with a thin film which appears green under the microscope. These films often appear beautifully iridescent in the hand specimen.

The groundmass consists of excessively minute elements, but under high powers the structure appears to be, on a very minute scale, the usual one of a basalt, the rock consisting wholly of crystallised minerals without any interstitial glass. The constituent minerals are augite and plagioclase in approximately equal proportions, and a rather large proportion of iron ore, perhaps $\frac{2}{5}$ of the mass of the base. The augite and plagioclase constitute minute prisms without any distinct tendency towards an ophitic mode of intergrowth. Occasionally the augite crystals are aggregated into globular patches of about 1 mm. in diameter in which the

component grains are of the usual size, but unaccompanied by any felspar.

The rock labelled 21-124 is almost identical with the one just described, except that the porphyritic augites are more numerous. The felspars and augites constituting the chief elements of the base are not so minute as in the previously described rock, the average dimension of the augite grains being 0.1 mm. The grains of iron ore are proportionately larger than in the previous rock, but the total amount of this mineral is somewhat less. The specific gravity is 3.04. The olivines in this rock are not iridescent.

This is the rock mentioned by Captain Lloyd as a "porphyritic dolerite of medium grain," and it is evidently a member of the older set of volcanics upon which the "massive lava" rests unconformably, and which there is every reason to regard as the local representative of the Deccan trap.

Minerals from geodes in the basalts.—In connection with these basalts, mention should be made of large specimens of agate, quartz, chalcedony, jasper, chert, opal and calcite, wholly similar to those scattered all over the areas of Deccan trap in India and, like them, evidently derived from large spherical geodes, or irregular fissures. The red hæmatitic hornstone 21-174 is a substance seldom met with in connection with the peninsular Deccan trap, but very common amongst its extra-peninsular representatives in the Arakan Yoma, the Andaman Isles, and Baluchistán and Persia.

The agates and jaspers have evidently been picked up lying loose on the ground, as is usually the case with the specimens from the peninsular Deccan trap. The large calcite specimen, 21-122, is still adhering to a fragment of vesicular basalt, much impregnated with calcite, and rather decomposed, in which the only minerals still recognisable are the felspars.

Sandstones.

The majority of the sandstones from the Dala region are whitish to pinkish rocks consisting of quartzose elements. The quartz is not of volcanic origin. The rocks are either fine grained, with elements not exceeding 1 millimetre in diameter, or else they pass into a conglomerate of small pebbles, the largest among which do not greatly exceed 1 centimetre.

From the constitution of the above-mentioned rocks, it is not possible to make out their stratigraphical relations to the volcanics. In one instance, however (21-158), the quartz grains are associated with numerous volcanic fragments of various sizes, the rock being intermediate between a normal sandstone and a volcanic breccia, and there is no doubt that this particular rock must be contemporaneously interbedded with the volcanic strata.

Probably, too, of volcanic origin are certain grey sandstones consisting of small angular grains of quartz scattered through a dust-like material (specimen 21-155).

THE SALEIK COLLECTION.

The specimens from Saleik are less numerous than those from Dala, but consist of a similar assemblage of forms.

They include the following rocks:—

Devitrified rhyolite (21-165).

Brecciated rhyolite (21-166).

Altered basalts or andesite basalts (21-167, 170).

Agate and "green earth" from a geode (21-172).

Sandstone with volcanic material (21-168).

Ordinary sandstones (21-171, 173).

Acid Rocks.

The devitrified rhyolite numbered 21-165 is a compact spherulitic rock with subconchoidal fracture and stony or slightly resinous lustre. The more or less confluent spherules, about 1 cm. in diameter, of white and purplish colour, scattered through a dark greenish grey, base with occasional red spots, give to the material a mottled appearance. The specific gravity is 2.57. Examined in thin slices under the microscope it appears obscurely crystalline and, to a large extent, isotropic, with a very evident streaky flow-structure, the lines of flow encircling a few orthoclase phenocrysts averaging about 1 millimetre in length. These crystals are scattered at very distant intervals and are not at all conspicuous in the hand-specimen, where they appear as small pink patches showing the characteristic pearly cleavage of the mineral.

The single specimen of a brecciated rhyolite, 21-166, is partly impregnated with secondary calcite, giving a peculiar sheen to some

of the fracture surfaces, but otherwise presents no features of special interest.

Basic Rocks.

The representatives of the basic group in the Saleik collection, so far as can be made out from the altered condition of the specimens, appear to belong to the highly felspathic variety of basaltic rocks such as commonly occur in the Deccan trap of India. There is no recognisable mineral other than the plagioclase feldspars, and these are so much altered and of such small dimensions that they cannot be accurately referred to any particular species. The low specific gravity points to a class of rocks intermediate between andesite and basalt, but this may be merely a consequence of their decomposed condition and vesicular structure. The specimens are greatly impregnated with secondary calcite.

One of the specimens, 21-167, is a rusty-red rock with a sharp line of separation dividing it into two portions, one of which is crowded with small vesicles about 1 mm. in diameter, while the other is more compact. The specific gravity, so far as can be made out in such a porous material, is 2.69. The rock is extremely fine-grained and probably cryptocrystalline, and so obscured by decomposition products when seen in thin sections, that a microscopic examination fails to reveal any distinct features.

The rock 21-170, with a specific gravity of 2.68, has the appearance of a greyish-lilac basalt crowded with spheroidal masses of "green earth" representing infilled vesicles. These spherules average 5 mm. in diameter and constitute about one-third in bulk of the rock. Examined in thin sections under the microscope, the rock is found to consist essentially of closely felted elongated plagioclase prisms, averaging 0.15 mm. in length. The interstices between the plagioclase prisms frequently exhibit outlines suggesting the shape of minute augite prisms, but the original material has been entirely replaced by secondary calcite. There are also outlines indicating the former existence of porphyritic crystals averaging 0.5 mm. in diameter, which may have been either augite or olivine or both, but these are entirely replaced by decomposition products.

The glauconitic "green earth", which principally occupies the large vesicles, appears, in thin sections, either milky or opaque or else translucent, in which case it shows, between crossed nicols, a minute mosaic of radiating tufts with fairly low double refraction. Calcite and chalcedony also partly fill the vesicles.

Sandstones.

Amongst the sandstones from Saleik there are some fine-grained green rocks made up of very angular fragments, of which about half are ordinary quartz grains of non-volcanic appearance, while the remainder are of volcanic origin, largely fragments of crypto-crystalline rhyolite. They also include opaque grains of iron ore with metallic lustre. The specific gravity is 2.70.

The remaining sandstones are ordinary white or pink quartzose rocks varying from a fine-grained material to a pebble-bed.

Rocks from the Aden Volcano.

The specimens from the pleistocene volcanic formation of Aden include a fragment of a friable red ash, and some dark more or less vesicular olivine-andesite-basalts or basic andesites. The specimens are too few to add anything to General McMahon's description of a much larger collection published in the *Records of the Geological Survey of India*, Vol. XVI, pages 145—158.

Minerals of Commercial Value.

The collection does not contain any metallic ores. Limestones of good quality appear to occur abundantly in the Jurassic series. Some of the compact bright-green ash-beds, if available in large blocks or slabs, would constitute a handsome decorative material.

NOTES ON UPPER JURASSIC FOSSILS COLLECTED BY
CAPTAIN R. E. LLOYD NEAR ADEN. BY G. H.
TIPPER, M.A., F.G.S., *Assistant Superintendent, Geological Survey of India.* (With Plates 35 and 36.)

THE fossils which form the subject of these notes occur in a hard, black, distinctly carbonaceous limestone. They are generally badly weathered and the shell substance has been replaced by crystalline calcite covered with a thin film of dark brown iron oxide. It seems to be this film which has preserved the outline in many cases. It is impossible to develop them in any way, and their determination is a matter of considerable difficulty.

From the similarity of the matrix and the state of preservation of the fossils, there is little doubt that all of them, with one exception, are from the same deposit. The exception is an indeterminable fragment of an ammonite (*Perisphinctes*?) in a light greyish limestone. It is a water-worn boulder and the matrix is so dissimilar from that of the rest that it is obviously from quite a different deposit.

The only paper with which I am acquainted dealing with Jurassic fossils from Arabia is one by Messrs. R. B. Newton and G. C. Crick entitled "On some Jurassic Fossils from Arabia", in the *Annals and Magazine of Natural History*, series 8, Volume 2, No. 7, pp. 13—30, Pls. 1—3.

In this paper a collection of fossils made by Major Hazelgrove in the Aden Hinterland is described.

These fossils are so very similar to those under discussion that the determinations and correlations suggested are of great importance. The following species are identified :—

1. *Parallelodon egertonianum* Stol. sp.
2. *Nucula cuneiformis* Sow.
3. *Trochus arabiensis* R. B. N.
4. *Nerinea* cf. *desvoidyi* d'Orb.

5. *Nautilus* cf. *hexagonus* Sow.
6. *Perisphinctes* cf. *torquatus* Sow. sp.
7. " cf. *subdolos* Font.
8. " cf. *abadiensis* Choff.
9. *Perisphinctes* cf. *Pottingeri* Sow. sp.
10. *Oppelia* ? sp.
11. *Belemnites* cf. *hastatus* de Blav.

Newton concludes that the lamellibranchs and gastropods point to an age later than Bathonian, probably Sequanian, and that they may be correlated with the Spiti shales and certain deposits in Kutch (Kachh) on the one hand and with the Bihin limestones on the other. The material on which Crick bases his conclusions is in a very bad state of preservation, being generally compressed and weathered, while in no case are the sutures visible. It certainly seems to me that the suggested identifications are somewhat far-fetched and that the ammonites are not sufficiently well preserved to admit of an exact correlation of the Arabian deposit with those of any other region.

The following are the notes on Captain Lloyd's fossils :—

***Belemnites* cf. *tanganensis*.** Futterer. Plate 35, figs. 2 and 3.

Zeit. d. g. Gesell., xlvii, p. 30, Pl. 5, figs. 2 and 3.

There are a number of fragments which obviously belong to the same species of belemnite. The characters agree so well with those of *B. tanganensis* that they are extremely closely allied, if not specifically identical. The rostrum is moderately long, slender, sub-hastate. The canal is somewhat deep and broad and runs almost the whole length of the rostrum, not quite reaching the apex. The cross-section is oval, flattened on the furrowed side, but rounded on the opposite side. Futterer says that this species has no near relative amongst the Indian Jurassic belemnites, and I have, by direct comparison with Waagen's types, been able to satisfy myself that such is the case.

This specimen differs completely from that figured by Crick. *Ann. & Mag. Nat. Hist.*, ser. 8, Vol. 2, Pl. 2, f. 1, also from near Aden.

AMMONOIDEA.Genus: **Perisphinctes** Waagen.

Without exception all the ammonites collected can be referred to this genus. They form the major part of the collection and are so badly preserved that they cannot be identified. They have divided into groups according to character of the ribbing.

Perisphinctes sp. No. 1. (Plate 35, fig. 2.)

Ribs regular, somewhat sharp, fairly widely spaced and only slightly bent forward. Ribs bifurcate and trifurcate at about half the distance between the ventral border and the shoulder. There are no well-marked nodes at the bifurcating points. Whorls rounded.

This specimen has not suffered quite so much compression as the other ammonites. Its resemblance to the specimen identified by Crick as *P. cf. abadiensis* Choff., *loc. cit.*, Pl. III, f. 2, may be pointed out.

Perisphinctes sp. No. 2. (Plate 35, fig. 1.)

Ribs numerous, close set, sharp, almost straight, bifurcating regularly at a point a little over half the distance from the ventral edge to the shoulder, the bifurcations forming a regular V-shaped continuation with the main rib. This character is seen at one point only in the inner whorl.

Perisphinctes sp. No. 3. (Plate 36, figs. 1, 2, and 2a.)

A very compressed fragment. Ribs sharp, widely spaced, regular, bent forward, bifurcating at about half the distance from the ventral edge to the shoulder. Slight nodes at the bifurcation point. The resemblance to the specimens identified by Crick as *P. cf. torquatus* Sow. sp. may be pointed out.

Perisphinctes sp. No. 4.

Ribs straight, sharp, bifurcating near the ventral edge of the whorl. Very badly compressed fragments.

GASTROPOD.

Genus et species indet. (Plate 36, fig. 7.)

Four specimens of a fusoid shell are represented in the collection. The spire is long, narrow and acuminate. The whorls, increasing regularly in size, are ornamented by transverse nodes and fine spiral lines which are particularly noticeable on the lower part of the whorls. The aperture is unfortunately not complete. It is prolonged into a moderately long inferior canal, the full extent of which is not seen. The inner lip is thickened and reflexed. The outer lip is broken. Probably this shell belongs to one of the fusus-like winged genera and the wings have been broken off. In shape and ornamentation it greatly resembles *Dicrolema* (*Pietitia*) *seminudum* Heb. & Desl. sp., figured by Cossmann, *Essais de Paléonch.*, Vol. VI., Pl. IV, f. 1.

LAMELLIBRANCHIATA.

Paralekodon egertonianum Stol. sp. (Plate 35, fig. 1.)

Three specimens which show the characteristic ornamentation of this species are represented in this collection. Stoliczka who founded the species assigned it to the Lower Oolite. Recently while examining collections made in Thibet by my colleague, Mr. Hayden, I came across several specimens of this lamellibranch associated with *Stephanoceras humphresianum* Sow. sp., so that it is obviously one with a long range in time.

Pinna sp. (Plate 36, fig. 5.)

A single broken specimen showing portions of both valves is represented in the collection. The ornamentation consists of irregularly spaced wavy ribs crossed at right angles by numerous fine lines. In its type of ornamentation it resembles *P. ledonica* de Loriol, "Etude sur les mollusques et brachiopodes de l'Oxfordien supérieur et moyen du Jura ledonien," 3^{me} partie, *Mem. Pal. Soc. Suisse*, Vol. XXXI, Pl. XXIII, f. 3. It differs very considerably in size and shape. I have not been able to find any *Pinna* quite like this Arabian form.

Trigonia sp. Group of *Costatae*. (Plate 36, fig. 6.)

The ribs are fairly widely spaced and ten in number. They do not run quite to the carina, but are separated from it by a slight groove. The posterior portion of the shell is obscured by matrix and cannot be got at.

It shows considerable likeness to *T. brevicostata* Kitchin, Jurassic Fauna of Cutch, *Pal. Ind.*, ser. IX, Vol. III, pt. II, the Lamelli-branchiata, Genus *Trigonia*, Pl. II, f. 4 & 5. It also resembles in ornamentation the fossil figured as *T. pulbis* var. by Douvillé, Fossiles du Choa, *B. S. G. F.*, ser. 3, t. XIV, Pl. XII, f. 14. It differs from both these shells in its relative proportions.

Pecten (Syncyclonena) sp.

A fragment of a right valve with part of the shell substance preserved can be readily referred to this sub-genus. The ornamentation is of very fine concentric striae of growth.

Cardinia? sp.

A single fragment may perhaps be referred to this genus.

CRINOIDEA.

Pentacrinus sp.

Several stem joints occur scattered through the various specimens.

The present study does not shed much light on the age of the Arabian deposits, but I think that every one will agree that the fossils figured here have a distinctly Upper Jurassic facies.

EXPLANATION OF PLATES.

PLATE 35.

Fig. 1.—*Perisphinctes* sp. No. 2.

Parallelodon egertonianum Stol. sp.

Hinge and part of the shell shows in the left hand bottom corner.

Fig. 2.—*Perisphinctes* sp. No. 1.

Belemnites cf. *tanganensis* Futterer.

Fig. 3.—*Belemnites* cf. *tanganensis* Futterer.

Showing the canal not quite continuous to the apex.

The extreme part of the apex is broken.

PLATE 36.

Figs. 1, 2, 2a.—*Perisphinctes* sp. No. 3.

Figs. 3, 4.—*Perisphinctes* sp. No. 4.

These show the compression which the ammonites have undergone.

Fig. 5.—*Pinna* sp.

Fig. 6.—*Trigonia* sp. group of *costata*.

Fig. 7.—Gastropod. Genus et spec. indet.

MISCELLANEOUS NOTES.

Note on the Occurrence of Samarskite in South India.

ABOUT three years ago, some specimens of this rare mineral were presented to the Geological Museum by Mr. P. N. Bose without any details of occurrence or locality. Samarskite is also mentioned as occurring in India in the Report on the work of the Imperial Institute, 1906 and 1907, p. 33, (1908), but no locality is mentioned. Recently, Mr. R. R. Simpson, Inspector of Mines, sent a small piece for identification, and he has since been able to visit the locality. The following details of the occurrence have been abstracted from his interesting account. The mineral occurs on the mica property of Mr. R. V. Kuppaswamy Iyer in the Sankara mica mine, village Gridalur, Nellore district, Madras Presidency. The mica is, as usual, found in pegmatite, but the pegmatite is not of the usual type, the quartz, felspar and mica being segregated into large masses sharply separated from one another. There are three mica pits, the largest being about 20 feet in diameter and 50 feet deep. It is in the sides and bottom of the latter that the mineral occurs as loose blocks between the books of mica. One piece seen *in situ* seemed to occur as a stringer at the contact of the felspar and mica. The mineral occurs massive without crystalline form and in blocks of large size, a broken specimen in the collection weighing 5,448 grms. (13 lbs.). The surface is covered with a reddish brown film. It breaks with a conchoidal fracture. The freshly broken surface has a black splendent resinous lustre. The specific gravity of a clean piece is 5.74. A complete qualitative analysis by Mr. Blyth proved beyond doubt that the mineral was samarskite.

[G. H. TIPPER.]

INDEX TO VOLUME XXXVIII.

SUBJECT.	Page.
Abu, chlorine in rain water of	169.
Accidents at coal mines	75.
<i>Aceratherium blanfordi</i>	60.
„ <i>perimense</i> , Lyd.	277.
Aden, jurassic fossils of	336.
—, manufactured salt, amount of	79.
Aden Hinterland, geology of	313.
—, petrology of	321.
Afghanistan, Fusulinidæ from	230.
Agate	332.
Ajmer, chlorine in rain water of	169.
Akarsani Hill, igneous rocks of	18.
Al Haki	316.
Allanrāyo subdivision	127.
Aloharu, china clay near	136.
—, fire-clay at	139.
Alunite	208.
—, at Sauni	209.
Alunogen	214.
Amber, value of, produced during 1908	72.
Anjhari, china clay at	135, 136.
—, fire-clay at	139.
<i>Ampullaria globosa</i> , Swains	30.
Andesites of Dala	327.
Anjiro	192.
Annandale, Dr. N.	15, 233.
<i>Anomia achææ</i> , Gray	30.
<i>Anoplotherium birmanicum</i>	277, 278, 279.
Antimony at Jhalawan	214.
— at Shekran	215.
Aravalli series	63.
<i>Arca adamsiana</i> , Dkr.	30.
„ sp.	265.
„ <i>theobaldi</i> , Noct.	265, 280.
Archæan gneiss	53.
— rocks	69.

SUBJECT.	Page.
Archaean rocks, Central Provinces	43.
—, Singhbhum	18.
<i>Aricia humerosa</i>	280.
„ (?) <i>moneta</i> , Linn.	30.
<i>Arietites</i> sp. aff. <i>bisulcatus</i>	26.
Artesian well at Karikal	20.
— possible in the plains of Jhau and Kej in Baluchistan	213.
Ashton, F.	177.
Asola, iron-ore at	309.
Aukmanein	271, 272.
Aunghan	49.
Avagul, coal at	215.
Bagh beds, age of	22.
—, ammonites of	21.
Bagmar, fire-clay at	139.
Bagmara, china clay near	134.
Bairma river, dams in	39.
Balaghat, production of manganese-ore in 1907 and 1908	78.
Balaghat district	44.
<i>Balanus tintinnabulum</i> , Linné	273, 303.
Ball, V.	137.
Baluchistan, alunogen	214.
—, antimony	214.
—, artesian wells	213.
—, barytes	214.
—, coal	215.
—, copper	215.
—, flysch in	190.
—, geology of	189.
—, irrigation in	211.
—, lead.	214.
—, Liassic and Neocomian fossils of	25.
—, licenses granted in 1908	119.
—, mineral concessions granted in	80, 118.
—, Neocomian	29.
—, petroleum	214.
—, production of chromite in 1907 and 1908	73.
—, production of coal in 1907 and 1908	74.
—, recent formations in	203.

SUBJECT.	Page.
Baluchistan, sulphur	214.
———, survey of	60.
Bamini river	36.
Banbyin, fish teeth from	293.
———, geology of	271.
———, prospects of oil at	290.
Bania Pani, occurrence of magnesite north of	211.
Banswara	63.
Bargo, fire-clay at	139, 142.
Bara Khatta	257.
Barytes	211.
——— at Kalat	214.
——— at Las Bela	214.
——— at Pabni	214.
——— at Sarmowli	214.
‘Basalskclot’	242.
Basalt, exceptional, of Dala	330.
——— of Dala	329.
<i>Batissa crawfordi</i>	30.
„ <i>kodaungensis</i>	30.
„ <i>petrolei</i>	30.
„ <i>yehwincensis</i>	30.
Beldongri, vredenburgite at	17.
<i>Belemnites</i> cf. <i>tanganensis</i> , Futterer	337.
„ (<i>Duvalia</i>) <i>dilatata</i> , Blainv.	29.
Belemnite shale of Baluchistan	29.
Bellarpur coal-field, output of 1907 and 1908	74.
Bémé	45, 48.
Bengal, china clay in	133—138.
———, fire-clay of	39.
———, glass-making sands of	39.
———, licenses granted in 1908	119.
———, mineral concessions granted in	81, 118.
———, production of coal in 1907 and 1908	74.
———, production of iron-ore in 1908	76.
———, production of manganese-ore in 1907 and 1908	77.
———, see Singbhum, Gangpur	42.
Bengal Iron and Steel Co.	41.
Bentinck Island	54.
Bhagalpur district	142, 144.
Bhagathoro	61.
Bhairagon, copper workings at	35.
Bhandara district	44.

SUBJECT.	Page.
Bhandara, production of manganese-ore in 1907 and 1908	78.
Bhander series	62.
Bhopal	63.
Bhukhanda, china clay at	134.
Bhulgora, fire-clay at	139, 140.
Bikaner	183.
———, chlorine in rain water of	169.
——— coal-field, output of, 1907 and 1908	74.
Bilih	318.
Bissl, iron-ore at	311.
Blanford, H. F.	135, 142.
———, W. T.	60.
Bleek, Dr. A. W. G.	12.
Blyth, T. R.	8, 14, 341.
Bolan	192.
———, petroleum in	214.
———, sulphur in	314.
Bombay, export of manganese-ore through, during 1907 and 1908	78.
———, licenses granted in 1908	120.
———, mineral concessions granted in	82, 118.
———, production and value of gold in 1907 and 1908	76.
———, production of manganese-ore in 1907 and 1908	77.
Boraghat, fire-clay at	139, 140.
<i>Boselaphus</i> sp.	277.
Bose, P. N.	13, 20, 341.
<i>Bouleiceras</i>	28.
Brahmapuri	68.
Braunite in Gangpur	43.
Brown, J. Coggin	6.
Buckley, G.	166.
Bugti	60.
Building stones in Central India	69.
Burari, fire-clay at	139, 140.
Burma, licenses granted in 1908	120.
———, Lower, geology of part of	259.
———, mineral concessions granted in	85, 118.
———, <i>Ostrea latimarginata</i> in	127.
———, Pegu inlier in	152.
———, petroleum	45.
———, production and value of gold in 1907 and 1908	76.
———, production of tin in 1908	79.
———, survey of	45, 53, 62.

INDEX.

SUBJECT.	Page.
Burma, Upper, Tertiary of	29.
Burma Oil Co.	29, 127.
Bushby Island	54.
“ Calcareous region ”	190.
————— description of	191.
————— geological formations constituting the	198.
Calcite	332.
Calcutta, estuarine beds under	30.
—————, export of manganese-ore through, during 1907, and 1908	78.
Calcutta Pottery Co.	133, 136, 137.
Cancellina	244.
Cantor	53.
Cape Copper Co.	36.
<i>Carcharias gangeticus</i> , M. & H.	298.
„ (<i>Aprionodon</i>) <i>frequens</i> , Dames	295.
„ (<i>Aprionodon</i>) sp.	292.
„ (<i>Prionodon</i>) <i>collata</i> (ex-Cope M.S.)	296.
„ (<i>Prionodon</i>) <i>egertoni</i> , Agass.	295.
„ (<i>Prionodon</i>) sp.	292.
<i>Carcharodon angustidens</i> , Agass.	299.
„ <i>lunceolatus</i> , Ag.	294, 299.
„ <i>megalodon</i> , Ag.	293.
„ <i>megalotis</i> , Agass.	294, 299.
<i>Cardinia</i> sp.	340.
Carnac Island	56.
Cassiterite	56, 57, 58, 59.
Cavern Island	54.
Central India, dams in	39.
—————, diamonds, value of, in 1907 and 1908	75.
—————, production of coal in 1907 and 1908	74.
—————, production of manganese-ore in 1907 and 1908	77.
—————, survey of	62.
Central King's Island	54.
Central Provinces Exhibition	16.
—————, fish fossils from	30.
—————, gondite series in	19.
—————, iron-ores of Chanda	308.
—————, licenses granted in 1908	122.
—————, manganese mines, inspection of	44.
—————, manganese deposits of	43.

SUBJECT.	Page.
Central Provinces, mineral concessions granted in	90, 118.
----- production and value of gold in 1907 and 1908	76.
-----, production of coal in 1907 and 1908	74.
-----, production of manganese-ore in 1907 and • 1908	77.
-----, survey of	68.
<i>Ceratrotrochus</i>	274.
<i>Cerithium</i> sp.	273.
Cerussite	215.
<i>Cervus</i> sp.	277.
Ceylon, export of Indian coal to	75.
Chaibasa	19, 34, 42.
Chalcedony	332.
Chalcocite in Singhbhum	36, 37.
"Chalk Hills," production of magnesite in 1907 and 1908	77.
<i>Chamaerops Ritchieana</i> , Griff	215.
Chanda, iron-ores of	308.
Chanda district, iron-ores in	69.
Chehiltan	192.
Chhatisgarh, possibility of manganese deposits	44.
Chhindwara, production of manganese-ore in 1907 and 1908	78.
Chhindwara district	44.
Chhota Khatta	257.
Chikhila	44.
Chilgo, china clay at	136.
-----, fire-clay at	139, 142.
China clay	133—138, 144, 146.
Chindwin district, Lower	46.
<i>Chaeromeryx</i>	278.
Chota Nagpur, iron-ore in	41.
Christie, A. K.	7, 14.
----- (with Sir T. H. Holland), on the origin of the salt deposits of Rajputana	51, 154.
Christmas Island	54.
Chromite in Singhbhum	19, 34.
-----, production of	73.
-----, value of, produced during 1908	72.
Chrysocolla in Singhbhum	36.
<i>Chauria cucularis</i>	66.

SUBJECT.	Page.
Coal	190.
—, analysis of, from Gilhurria	150.
— at Avagul	215.
— at Gilhurria (Rajmahal Hills)	149.
— at Lohandia	138, 147.
— at Shirinab	205.
—, export of	75.
—, half-way between Johan and Ziarat	204.
—, import of	75.
— near Mastung	205.
—, output of Gondwana	74.
—, output of Tertiary	74.
—, prospect of, in Ghazij series	205.
—, prospect of, in plateau from Gishk Hill to Melabi	205.
—, value of, produced during 1908	72.
<i>Calopoceras</i> , range of	22, 23.
„ <i>Bosei</i> , Vred.	22.
„ <i>Scindia</i> , Vred.	22.
Colgong, geology of Patraghatta near	142.
Collins Island	56.
<i>Comus qvaensis</i> , Noet	265.
„ sp.	263.
Copper	210, 215.
— between Ziarat and Johan	210.
— in Singlabhum	35.
<i>Corbula socialis</i> , K. Martin	265, 273.
Cornish-stone at Kasdeh	146.
— at Patraghatta	146.
Cotter, G. deP.	6, 10, 45, 62.
—, on Burmese oil-fields	46.
—, on <i>Dendrophyllia</i>	30.
—, on Gwegyo Hills	48.
—, on Taungtha Hills	47.
—, on Tertiary of Upper Burma	29.
—, on Yenangyat oil-field (northern part of)	362.
Craig, Cunningham	278, 279.
<i>Crioceras</i> sp.	29.
Cuddalore sandstones, fossil wood from	20.
<i>Cyrena (Batissa) petrolei</i> , Noet.	277.
„ <i>crasfurdi</i> , Noet.	277.
„ <i>kodaungensis</i> , Noet.	302.
<i>Cytherea erycina</i> , Fav.	280.
„ „ occurrence of, in Upper Promie series	263.

SUBJECT.	Page.
Dabiyat	216.
<i>Dactyloceras cf. annulatum</i>	26.
Dala	313.
——, acid rocks of	325, 326.
——, andesites (doubtful) of	327.
——, basic rocks of	328—330.
Dalma Trap of Singhbhum	18.
Daltonganj coal-field, output of, 1907 and 1908	74.
Daman	213.
Daman-i-Koh, fire-clay beds in	140.
Damodini	218.
Dam sites in Central India and United Provinces	39.
Damuda sandstone, china clay in, at Mangal Hat	133, 137.
Dane, Sir Richard	159.
Daru, N. D.	7.
———, on alum in the Punjab.	32.
———, on oil-springs at Jaba, Punjab	51, 257.
Das-Gupta, Hem Chandra	9.
Dasht-i-Kavir	182.
Dasht-i-Lut	182.
Datta, P. N.	5, 10.
———, on geology of Chanda district	68.
———, on iron-ores	69.
———, on iron-ores of Chanda, Central Provinces	308.
Davies, H. J.	127, 264.
Davies Island	54.
———, cassiterite in	56.
Deb, Satya Sundar	136.
Deccan Trap	67, 68.
———, probable representatives of, in Aden	323.
Degana	161.
Delhi series	64.
<i>Dendrophyllia macroriana</i>	30, 304.
<i>Dendrophyllum</i> sp.	265.
Dewalgaon, iron-ore at	310.
Dewas	63.
Dhalbhum, copper in	35.
Dhamnar, cave temples of	68.
Dhamni coal-field, china clay at	136.
Dharwar, production and value of gold in 1907 and 1908	76.
Dharwar, Central Provinces	19.
———, Singhbhum	18, 36, 41, 42.
Dhasan river, dam in	39.

SUBJECT.	Page.
Dhoba Hills	41.
Dhumni, fire-clay at	139, 140, 142.
Diamond-drilling in Singhbhum	37.
Diamond, production of	75.
———, value of, produced during 1908	72.
Didwana	155, 161.
Diener, C.	12, 13.
<i>Dinothierium indicum</i>	60.
<i>Dione</i> sp.	263, 265.
Ditmas, F. L.	31.
Dodhání, china clay at	134, 135.
Dolerite of Dala	328.
——— of Singhbhum	18.
<i>Doliolina</i>	242.
Domel	54.
Dongargaon, fossil fish from	30.
Dongor Parashea	31.
Duarparan, copper workings at	36.
Duff, Gordon	38.
Dumabhita, fire-clay at	130, 142.
Dunstan, Prof. W. R.	13.
Eastern Bengal and Assam, licenses granted in 1908	123.
———, mineral concessions granted in	114, 118.
———, production of coal in 1907 and 1908	74.
Elephant group	55.
Elphinstone Island	53.
<i>Eoserranus</i>	31.
Epidiorites of Singhbhum	18.
Erinpura	64.
<i>Eudesia</i> sp.	27.
Export of coal, 1907 and 1908	75.
——— of jadeite through Rangoon, 1907 and 1908	77.
——— of kerosine in 1907 and 1908	79.
——— of manganese-ore, 1907 and 1908	78.
——— of mica in 1907 and 1908	78.
——— of paraffin wax in 1907 and 1908	79.
——— of saltpetre in 1907 and 1908	79.
Falodi	155, 161.

SUBJECT.	Page.
Farah Rud	217.
Father and Son Island	54.
Fermor, L. L.	5, 10, 12, 13.
———, on chromite in Singhbhum	34.
———, on copper-ores in Singhbhum	35.
———, on Dalma trap	18.
———, on gondite series	19.
———, on granophyres of Akarsani Hill	18.
———, inspection of manganese mines	44.
———, on iron-ores in Singhbhum	41.
———, on magnesian rocks	19.
———, on manganese-ore deposits	42.
———, at Nagpur Exhibition	16.
———, on new manganese minerals	16.
<i>Ficula</i> sp.	263, 273.
Fire-clay	59, 133, 138— 142, 146.
Five Sisters Island	54.
<i>Flabellum distinctum</i> , M. E.	263.
Fletcher Island	53.
Flysch	190, 202.
Foraminifera, wind-borne, in the desert sand	162.
Fort Munro	61.
Fossil wood in Ayu stream	60.
———, in Burma	46.
———, of the Cuddalore sandstones	20.
<i>Fusulina</i> , Schellwien's classification of	239.
„ structure of the shell substance of	232.
„ systematic position of	238.
„ Yabe's classification of	280.
„ <i>elongata</i> , Shumard.	247.
„ <i>uralica</i> , Krotow	244.
Fusulinidæ, dimorphism in	251.
——— from Afghanistan	230.
Gaj	220.
Gaj beds, partial reference of <i>Orbiculina</i> beds to	20.
Gaj fossil in Burma	127.
——— in Upper Promé series	264.
Galena in Maingay's Island	57.
——— in Mergui	57.
<i>Galeocerdo latidens</i> , Ag.	292.

SUBJECT.	Page.
<i>Gangamopteris cyclopteroides</i> , Fstm.	31.
Gangao, dams in	39.
Gangpur	77.
———, manganese-ores of	20, 43.
Gangpur State, manganese in	43.
Gargava, Sheoprasad	9.
Gariaghar, manganese-ore at	44.
Garividi, vredenburgite at	17.
Garrick, H. B. W.	14.
Gastropod, gen. ind. sp. ind.	338.
<i>Genola iravadica</i> , Noet.	265.
Ghatpande, S. R.	9.
Ghatsila	38.
Ghazij, prospect of coal in	205.
Ghazij series in Sarawan	195.
Gilhurria, coal at	149.
———, fire-clay at	139, 140.
———, sketch map of the country around	150.
Giridih coal-field, output of, 1907 and 1908	74.
Gladstone shaft, Singhbhum	37.
<i>Glossopteris</i> in Kashmir	70.
<i>Glossopteris indica</i> , Schimp	31.
Gobi formation	217.
Goilkora	42.
Golabgarh Pass	70.
Gold in Lower Burma	56, 58.
———, production of, during 1908.	75, 76.
———, value of, produced during 1908	72.
Golden stream	58.
Gomharia, granophyre at	18.
Gondite	19.
Gondite series	12.
———, in Central Provinces	19.
———, in Gangpur	43.
Gondwanas in Kashmir	69.
Governor, Swinton Island	54.
Gowari Warhona	44.
———, manganese-ore included in pegmatite	43.
Granite	53.
Granites in Erinpura and Siwana	64.
Granophyres of Singhbhum	18.
Grant Island	53.
Graphite, production of	76.

SUBJECT.	Page.
Graphite, value of, produced during 1908	72.
Great Western Island	53.
Gregories Island	56.
Gt. Tenasserim rivers	55.
Gugri, fire-clay at	139, 142.
Gupta, Bankim Behari	14, 31, 187.
Gwegyo Hills, examination of	48.
Gypsum	40, 183, 208, 209.
 Hab	 192.
Hacket	62.
Hakigora, iron-ore at	41, 42.
Hallowes, K. A. K.	6, 10.
———, on copper-ores of Singhbhum	35.
Hamirpur, gypsum in	40.
Harpalpur	39.
<i>Harpoceras</i> cf. <i>serpentinum</i>	26.
Harut Rud	217.
Hayden, H. H.	4, 10, 14, 16, 20.
———, on fusulinids from Afghanistan	230.
Hayes	53, 54.
Hazara coal-field, output of, 1907 and 1908	74.
Hazelgrove, Major	336.
Healey, Miss M.	13.
Heinza Basin, gold in	58.
———, tinstone in	58.
———, wolfram in	58.
Helmand river	217.
Hematite	69, 308, 309, 310, 311, 312.
Hematite-quartzites	42.
<i>Hemipristis serra</i> , Agass.	273, 274, 293, 297.
„ <i>simplex</i> ? Stuart	296.
Heron, A. M.	7, 10, 62, 63, 67.
High Island	54.
<i>Hildoceras</i> sp.	26.
Hinda river	58.
Hindu river	55.
———, cassiterite in the	58.
———, gold in the	58.
Hingláj, equivalence of, in Burma	128.

SUBJECT.	Page.
<i>Hipparion punjabiense</i> , Lyd.	277.
<i>Hippoptamus irracadicus</i> , F. & C.	277.
<i>Hippurites</i>	216, 222.
———, age of, from Scistan	228.
——— in Asia Minor	228.
——— in Persia	228.
<i>Hippurites cornucopiæ</i> , DeFr.	228.
„ <i>gosaviensis</i> , Douvillé	223.
„ <i>Loftusi</i> , Woodw.	228.
„ <i>vesiculosus</i> , Woodw.	228.
Hira Lal Moti Lal Shah	9.
Holland, Sir T. H., General Report for 1908	1, 10, 12, 13.
———, mineral production during 1908	71.
———, on Twinza reserves	48.
——— and Christie, W. A. K., on the origin of the salt deposits of Rajputana	51, 154.
Hooper, D.	157, 168.
<i>Hoplites amblygonius</i> , Neum.	29.
Horsborough Island, gold in	56.
Hughes, T. W. H.	69.
Hura	39.
Hura, fire-clay at	139, 140.
Hura coal-field, china clay at	136, 137.
Hurreye	31.
Hyderabad, production and value of gold in 1907 and 1908	76.
———, production of coal in 1907 and 1908	74.
<i>Hyalithellus</i>	66.
Import of salt in 1907 and 1908	79.
Indore	63.
'Infra-trappean,' fluviatile representative of Bagh Beds	21.
Inter-trappeans	67.
——— at Jhalawar	67.
Iron in Mergui	57.
Iron island	54.
Iron-ore, analyses of, from Pipalgaon and Ratnápúr	312.
——— at Asola	309.
——— at Bissi	311.
——— at Chota Nagpur	41.
——— at Dewalgaon	310.
——— at Lohara	308.
——— at Pipalgaon	311.

SUBJECT.	Page.
Iron-ore at Ratnápúr	312.
—— at Singhhum	41.
—— at Yenak Hill	312.
—— near Lohara	69.
—— of Central Provinces	308.
——, production of	76.
——, value of, produced during 1908	72.
Irrawaddy series	129, 266, 273.
——, basal beds of, at Yenangyaung, equivalent to M. Siwalik	130, 277.
——, fossils in the	273.
Irrigation in Baluchistan	211.
Iyer R. V. Kuppaswamy	341.
Jaba	51.
——, oil at	257.
Jabal Asoda	316.
Jabal Harir	314.
Jabal Jihaf	314.
Jabal Shahad	316.
Jadeite, production and export of	77.
——, value of, produced during 1908	72.
Jadestone, <i>see</i> Jadeite.	
Jaipur, chlorine in rain water of	169.
Jaora	63.
Jammu	70.
Jamsar	183.
Jasper	332.
Jenkins Island	56.
Jhabua, manganese-ores of	20, 43.
Jhalawan	191, 192.
——, antimony at	214.
——, geology of	189.
——, lead at	214.
——, liassic beds in	192.
——, M. liassic beds in	26.
——, western border of, flysch in	202.
Jhalawar, inter-trappeans at	67.
——, laterite in	67.
Jherriah coal-field, output of, 1907 and 1908	74.
Jiajore, fire-clay at	139, 140, 142.
Jodhpur, chlorine in rain water of	169.

SUBJECT.	Page.
Jodhpur State	183.
Johan coal	204.
Joly, Prof. J.	164.
Jones, H. C.	7, 10, 62.
———, on Deccan Trap and laterite	67.
———, on Vindhyan series	65.
———, on Vindhyan fossils	66.
Joti Pershad, Lala	9.
Jubbulpur, production of manganese-ore in 1907 and 1908	78.
Juddite	17.
Julia Island	55.
Julian Island	53.
Jurassic in Sarawan	192.
——— in Aden Hinterland	223, 336.
Kabat, Pegu series of	29.
Kacharwahi	44.
———, juddite at	17.
Kachh, presence of <i>O. latimarginata</i> in	127.
Kachhi, favourable prospect of petroleum at	205, 208.
Kachor-Rewassa	155, 161.
Kaimur scarp	65, 66.
Kaimur series	62, 66.
Kalat	25.
———, barytes at	214.
Kalinati	41.
Kama, geology of	259, 270.
Kama clays	129, 130, 131, 132, 261, 265, 271, 273, 274.
Kan Berar, salt at	208.
———, sulphur at	208.
Kandri	44.
Kani	46.
Kankar	183.
Kaolin, <i>see</i> China clay.	
Karharbari bed in Kashmir	70.
Karikal, marine fauna at	20.
———, artesian well at	20.
Karikal fauna, approximate age of	21.
Karna	316.
Karwi, dams in	39.

SUBJECT.	Page.
Kasdeh	142, 143, 146.
Kashmir, <i>Orbitolina</i> from	20.
———, survey of	69.
Karanpur, china clay at	134, 135.
Katangi, china clay at	134.
Kathiawar, presence of <i>O. lutimarginata</i> in	127.
Kayinzu, oil seepage at	265, 269.
Kehdaung (Favoy district), cassiterite in	58.
Kelat, geology of	189.
Kellerschön, J.	16.
Ken river, dams in	39.
Kera Estate, copper in	36.
Khendel	154, 159.
Kharian	154, 159.
Kharsawan, copper in	36.
———, petrology of	18.
Khash Rud.	217.
'Khatta'	257.
Khujuria, fire-clay at	139, 142.
Khojagär	230.
Khorasan, <i>Orbitolina</i> from Persian	20.
Khost coal-field, output of, 1907 and 1908	71.
Kin, oil near	46.
King's Island, cassiterite in	56.
Kirthā, petroleum at	214.
Kirthar	61.
Kirthar series	191.
Kishen Singh, Lala	25, 62.
Kissering Island, cassiterite in	56.
Kodurite series	20.
Koh-i-Chako	219.
Koh-i-Dalil	218.
Koh-i-Khwaja	219.
Koh-i-Maku	222.
Koh-i-Maran	192.
Koh-i-Nahrāhu	222.
Koh-i-Siah	222.
Koh-i-Sultan	218.
Kojak bed	190.
Koolagyun	54.
———, laterites of	56.
Kosumbah	44.
Kola, dams in	39.

SUBJECT.	Page.
Kudada, iron-ore at	41.
Kukresor	65.
Kyaukwet, oil seepages near	46.
Labour in Indian coal mines in 1907 and 1908	74.
Laki	61.
Lameta beds	67.
———, age of, from evidence of fossil fish	31.
———, fluviatile representative of Bagh beds	21.
———, fossil fish in	30.
<i>Lamna spallanzanii</i> , Bonaparte	288, 293.
Las Bela	25, 189, 191.
———, barytes in	214.
———, favourable prospect of petroleum at	205, 206.
———, flysch in	202.
———, geology of	189.
———, liassic beds in	26.
———, magnesite in	211.
———, psilomelane in	211.
———, salt in	208.
———, sulphur in	208.
Laterite	55, 56, 67, 69.
LaTouche, T. D.	4, 10, 156, 162.
———, on gypsum in Hamirpur	41.
———, oh sites for reservoirs	39.
Laukisa, boring at	38.
Lead	57, 210, 214, 215.
Leda Hill, manganese at	42.
<i>Leda virgo</i> K. Martin	265, 273.
<i>Lepidosteus</i>	31.
Liassic beds in Jhalawan	192.
Liassic fossils of Baluchistan	25, 26, 27.
Liebethenite in Singhbhum	36.
<i>Lima cf. punctata</i> , Sow.	23.
„ (<i>Plagiostoma gigantea</i> , Sow.	28.
Limestones	335.
<i>Lithodermus</i> sp.	273.
Lithomarge in Mergui	55, 56.
Lloyd, R. E.	322.
———, on the geology of Aden Hinterland	313.
Loess	221.
Lohara, iron-ore at	69, 308.

SUBJECT.	Page.
Lohardaga district	18.
Lohunda, coal at	147.
Lohandia	133, 138—140.
Lomas, J.	172.
Lonkara Sur	155.
Lord Loughborough Island	54.
<i>Lucina globulosa</i>	274, 278.
Luni river	164, 177.
Macdonald, G.	142, 147.
Mach coal-field, output of, 1907 and 1908	74.
Madras, licenses granted in 1908	123.
———, mineral concessions granted in	114, 118.
———, production of manganese-ore in 1907 and 1908	77.
——— samarskite in	341.
Mafari	317.
Magnesian rocks of Singhbhum	19.
Magnesite	211.
———, production of	77.
———, value of, produced during 1908	72.
Magnetite	41, 56.
Magwe, Pegu inlier in	152.
Mahua Bathán	137.
Maingay's Island	53.
Majhafa	313.
Malhargarh	68.
Makum coal-field, output of, 1907 and 1908	74.
Malachite in Singhbhum	36.
Mallet, F. R.	313.
Manbhum district	18.
Mangal Hat, china clay at	133, 136, 137.
Mangalore	183.
Manganese	42, 43.
——— minerals	14.
——— mines, inspection of	44.
Manganese-ore	215.
———, exports of, during 1908-09	78.
——— in Las Bela	211.
——— of the Central Provinces	19.
———, production of, during 1908	77, 78.
———, value of, produced during 1908	72.

SUBJECT.	Page.
Maingay's Island, galena in	57.
Mansar	44.
Marcasite	211.
Mares district	314.
<i>Marginella (glabella) scripta</i>	265.
Maricn group	55.
Marri	60.
<i>Mastodon angustidens</i>	60.
„ <i>atidens</i> , Clift	277.
„ <i>pandionis</i>	60.
Mastung, coal near	205.
Matigara, boring at	37.
————— copper at	35.
Maungmeshauung, tin and wolfram in	57.
Mazar Drik	61.
McMahon, Sir Henry	216, 221, 313.
Mekran, geology of	189.
—————, prospects of petroleum in	205, 206.
<i>Melania</i>	47, 302.
Menda	154, 159.
Mergui, cassiterite in	53, 56, 57.
Mergui series	54.
<i>Merycopotamus dissimilis</i> , F. & C.	277.
Metcalfc Island	53.
Meteorites	15.
Meting shales	23.
Mianwali coal-field, output of, 1907 and 1908	74.
—————, district	257.
Mica, exports of	78.
———— in Mergui	56.
————, value of, reduced during 1908	72.
Middlemiss, C. S.	4, 12.
—————, on geological work in Central India and Raj- putana	62.
—————, on geology of Kashmir	69.
Minbu, fish teeth from	293.
Mineral oil, export of, in 1907 and 1908	79.
Mineral production, 1908	71.
Mining leases, grants of	119.
Mit Koh	218.
Mogoung sands	267.
Mohpani coal-field, output of, 1907 and 1908	14.
Monazite from Western Australia	15.

SUBJECT.	Page.
Mormugao, export of manganese-ore through, during 1907 and 1908	78.
Moscós Island	53.
Moulmein group	55.
Mourbhanj, marine fossils discovered in	20.
Mud volcanoes	45.
Mula	192.
Munjewara	69.
Muraroi	135.
Murwari, dams in	39.
Myingyan district	29, 46, 47.
Myitkyina, production and value of gold in 1907 and 1908	76.
Myitta, Tertiary strata in	59.
Mysore, production and value of gold in 1907 and 1908	76.
-----, production of chromite in 1907 and 1908	73.
-----, production of manganese-ore in 1907 and 1908	77.
Nagpur, production of manganese-ore in 1907 and 1908	78.
----- Balaghat area, manganese-ore of	20, 43.
----- district	44.
----- Exhibition	16.
Namayan, geology of	259.
-----, oil seepage at	265.
<i>Nannorhops Ritchiana</i> , Wild.	215.
Nargunjo	135, 139, 142.
Narke, G. G.	9, 35.
Nari series in the Bugti Hills	60, 61, 191.
Narukot, manganese-ore of	20, 43.
Nathé	272.
<i>Natica obscura</i> , Sow.	273.
<i>Nautilus</i>	48.
Neemuch	63, 64.
Nellore district, samarskite from	341.
Neocomian fossils of Baluchistan	25.
<i>Neoschwagerina</i>	243, 244, 248— 250.
<i>Nerinea</i>	223.
Nizam's Dominions, production and value of gold in 1907 and 1908	76.
Nobat Dakim	313.
Noetling, Dr. F.	156.
Northern India Salt Revenue	166, 177.

SUBJECT.	Page.
North-West Frontier Province, licenses granted in 1908	124. .
—, mineral concessions granted in	117, 118.
—, production of coal in 1907 and	
1908	74.
<i>Nummulites planulatus</i>	23.
„ <i>eredenburgii</i> , Prever	25.
Nunn, E. D.	166.
<i>Oboella</i>	66.
Oldham, Dr. T.	11.
—, R. D.	163.
Olen river, dams in	39.
Oil, Lower Burma	265, 269.
Oil, Punjab	51, 257.
<i>Olcostephanus asterianus</i>	29.
Ondwe, Pegu inlier at	152.
Ongbingwin, cassiterite at	57.
Opal	332.
<i>Orbiculina</i> beds	20, 21.
<i>Orbitolina</i>	20.
<i>Ostrea</i>	266, 303.
„ <i>canadensis</i> , Tk.	30.
„ <i>cucullata</i> , Bow.	30.
„ <i>flabellula</i> , Sow.	127.
„ <i>latimarginata</i> , Vred.	127, 128, 180, 264, 274, 275, 276, 292.
<i>Otodus appendiculatus</i> , Agass.	294.
<i>Otolithus</i>	187.
<i>Oxytoceras</i> sp.	26.
<i>Oxyrhina gomphodon</i> , Müller and Henle	288, 293.
„ <i>spallanzanii</i> , Bonaparte	288, 293, 294.
Pab	65.
Pabni, barytes at	214.
Pachbadra	51, 161, 169, 173, 177, 183.
Pachwara	39.
Padaukpin	131.
—, fish teeth from	293.
—, geology of	271.

SUBJECT.	Page.
Padaukpin, prospects of oil at	290.
Padaung, geology of	29, 259.
———, prospects of oil at	269.
Pagan Hills	298.
Pagaye, tin-bearing gravels at	59.
Page, J. J. A.	7, 10, 62.
———, on geology of Mergui	53.
———, on geology in Tavoy	57.
———, on minerals of Mergui	56, 57.
Pahari, dams in	39.
Paisuni river, dams in	39.
Pakokku district	46.
———, fish teeth from	294.
Pali manganese-mine	44.
<i>Paludina (Vivipara) bengalensis</i> , Lam.	30.
Panna, dam sites in	39.
Paraffin wax, export of, in 1907 and 1908	79.
<i>Parallelipedium protortuosum</i>	263.
<i>Paralleodon egertonianum</i> , Stol. sp.	339.
Parh limestones	222.
Parker Island	54.
Partabgarh	63, 64.
Pascoe, E. H.	6, 11, 12, 29, 62, 187.
———, on a Pegu inlier at Ondwe	152.
———, on <i>Dendrophyllia</i>	30.
———, on Mount Popa	46.
———, on Pegu beds of Burma	30.
———, on the oil of Lower Chindwin	46.
———, on the Yenangyaung oil-field	45.
Pataw	54.
Patraghatta, clays of	133, 134, 135, 136, 142, 146, 147.
Pauk Tein, wolfram in the tributary (Sanchè) of	59.
Payagyigon-Ngashandaung	29, 46, 48.
<i>Pecten</i>	223.
„ <i>ambungensis</i>	28.
„ (?) n. sp.	28.
„ (<i>syncyclonena</i>) sp.	340.
„ <i>vasseli</i> , Fuchs	130.
Pegu beds at Yenangyat	29, 302.
———, freshwater fossils in	30.

SUBJECT.	Page.
Pegu beds, marine fossils in	29.
Pegu inlier at Oudwe (Magwe district, Upper Burma)	152.
Pegu system, classification of	129.
———, fish teeth from	292.
———, known zones of	280.
———, on the recorrelation of	271.
Pench valley, Gondwana plants of	31.
——— coal-field, output of, 1907 and 1908	74.
<i>Pentacrinus</i> sp.	340.
<i>Perisphinctes</i> sp.	29, 338.
Petroleum	45, 46, 62, 153, 205—207, 214, 259, 269, 271, 276, 290, 307.
———, production of, during 1907 and 1908	79.
———, value of, produced during 1908	72.
<i>Pholadomya</i> cf. <i>idea</i> , d'Orb.	28.
<i>Pholas orientalis</i>	280.
<i>Phylloceras</i> sp.	29.
„ cf. <i>velledæ</i> , d'Orb.	29.
<i>Phyllothea indica</i> , Bunb.	31.
Piaram, china clay to the west of	137.
Pickering, W. H.	172.
Pickwick group	54.
Pig Island	56.
Pilgrin, G. E.	5, 13, 60, 277.
———, on Upper Tertiary beds of Baluchistan	60.
<i>Pinna</i> sp.	339.
Pipalgaon, iron-ore at	311.
Pipe-clay, available at Kasdeh	146.
———, available at Patraghatta	146.
<i>Pironaea corrugata</i> , Woodw.	228.
„ <i>persica</i> , Vredenburg	223, 226, 228.
Pir Pahar, china clay at	136.
Pir Painti-Dumka	134.
Pir Panjal	70.
Pishin, Tertiary age of	220.
<i>Placenticerus Minto</i> , Vred.	22.
<i>Plagioplychus</i>	223.
<i>Planorbis exustus</i> , Desh.	30.
Pleistocene beds in Baluchistan	61.
——— in Seistan	221.
<i>Pleurotoma Karenaica</i> , Noet.	265.

SUBJECT.	Page.
Pokaran	161.
Popa	46.
Porali	192.
Porali river, middle liassic fossils of	27, 28.
<i>Potamochoerus titan</i> , Lyd.	277.
Post-tertiary deposits in Baluchistan	61.
Presidency College, geological classes in	9.
Prome, Western, geology of	259.
Prome beds	129, 130.
Prome district, fish teeth from	292.
Prome series, equivalent to Gaj	129, 130, 263, 264, 268.
Prospecting licenses, grants of	119.
Psilomelane in Las Bela	211.
<i>Psymnophyllum</i>	79.
Pumpkin Island	56.
Punjab, oil-springs and alum shales of	51.
———, licenses granted in 1908	124.
———, mineral concessions granted in	117, 118.
———, oil in	257.
———, production and value of gold in 1907 and 1908	76.
———, production of coal in 1907 and 1908	74.
———, production of salt, including that of N.-W. Frontier	79.
Purani	41.
<i>Pycnodus</i>	31.
Quetta	220.
Quilon, <i>Orbiculina</i> beds of	20.
Rajabhita, china clay in nala near	134.
Rajdoha Copper Co.	36.
Rajmahal coal-field, output of, 1907 and 1908	74.
Rajmahal Hills, china clay in	133.
———, coal in	149.
———, fire-clay in	39, 133, 140.
———, sands suitable for glass-making	39.
Rajputana	183.
———, production of coal in 1907 and 1908	74.
——— salt	51.
——— salt deposits, on the origin of	154.
———, survey of.	62.
Rampura	63, 65, 67.

SUBJECT.	Page.
Rampur Hat	135.
Raniganj coal-field, output of, 1907 and 1908	74.
Ranikot series	23, 24.
Rao, M. Vinayak	8, 51, 60, 61.
Ratnápúr, iron-ore at	312.
Rau, S. Sethu Rama	8, 45, 47, 62, 152, 304.
Recent deposits of Mergui	55.
----- in Baluchistan	203.
Red bed	153, 278, 279.
Reed, F. R. C.	13.
Rewah series	62.
Rhodonite in Gangpur	43.
Rhyolite, Dala	325, 326.
Rock-salt	161, 182.
Rohri, clay at	157, 159, 140.
Ross Island	55.
Ruby, sapphire and spinel, production of	79.
-----, value of, produced during 1908	72.
Rupnagar	154, 159.
Russet Island, gold in	56.
Rutlam	63.
Sailana	63.
Saldaha, fire-clay at	139, 142.
Saleik, acid rocks of	333, 334.
Salem	77.
Salt	208.
--- at Kan Berar	208.
---, comparison of Sambhar, with oceanic waters	167.
--- in Las Bela	208.
---, production and import of	79.
---, Rajputana, origin of	51, 154, 165.
---, value of, produced during 1908	72.
Salt-lakes	155, 156.
Saltpetre, export of	79.
-----, value of, produced during 1908	72.
Salt Range coal-field, output of, 1907 and 1908	74.
Salt springs	156.
Samarskite at Gridalur	341.
Sambhar, chlorine in rain water of	169.
----- basin, river water in	159.

SUBJECT.	Page.
Sambhar Lake	173, 184.
———, salt resources of	154.
Sana	315
Sands of Rajmahal Hills	39.
Sandstones of Dala	332.
——— of Saleik	335.
Sanni, petroleum near	214.
———, sulphur near	214.
• Sapphire, <i>see</i> Ruby.	
———, value of, produced during 1908	72.
Saraikala, copper in	36.
Sarawan, geology of	26, 189, 192, 202.
Sarmowli, barytes at	214.
Sarwan district	190, 191, 192.
Saubolle, R.	35.
<i>Schwagerina</i> , definition of	243.
Scully, G. T.	166.
Scewin, oil seepages near	46.
Schwan	61.
Seistan	216, 217, 221.
Selenite	40, 41.
Sellore	53.
Sen-Gupta, Kiran K.	9, 35.
Serpentine	19, 34, 211.
Seton-Karr, W. S.	11.
• Shahpur coal-field, output of, 1907 and 1908	74.
Shaibi	314.
Shankar Lal, Byas	9.
Shekran, antimony at	215.
———, lead at	210, 215.
Shibar Pass	230.
Shirinab, coal at	205.
Shirinab river	192.
Shirinab valley, L. liassic beds in	26.
Simlong, fire-clay at	139, 140, 142.
Simpson, R. R.	341.
Simru, fire-clay at	139, 140.
Sind, presence of <i>O. latimarginata</i> in	127.
———, Ranikot series of, fauna of	23.
Singareni coal-field, output of, 1907 and 1908	74.
Singhbhum, chromite in	34.
———, copper in	35.
———, iron-ore in	41.

SUBJECT.	Page.*
Singhbhum, manganese in	42.
———, petrology of	18.
Singu oil-field	29, 47, 294.
Sir William James Islands	55.
Sitamau	63.
———, laterite in	67.
Sitapar, sitaparite at	17.
Sitaparite	17.
Sitsayan shales	129, 130, 131.
Siwaliks in Baluchistan	60, 61.
——— in Scistan	218, 220.
Siwana	64.
Smith Woodward, Dr. A.	13.
Snelus, J. E.	38.
<i>Sonjharis</i>	16.
Sonua	35.
Sor coal-field, output of, 1907 and 1908	74.
Spessartite in Gangpur	43.
<i>Sphyrna prisca</i> , Agass.	297.
Spinel, <i>see</i> Ruby.	
———, value of, produced during 1908	72.
<i>Spirifer Rajah</i>	70.
<i>Spiriferina di Stefanoi</i> , del Piaz	28.
„ nov. sp.	27.
„ <i>rostratu</i> Schloth	27.
„ <i>rostrata</i> var. <i>mad gascarensis</i>	28.
Steatite in Singhbhum	19, 41.
St. Luke's Island	54.
St. Matthew's Island	54.
Stoliczka, F.	313.
Stuart, M.	7, 13.
———, on china clay of the Rajmahal Hills	34, 133.
———, on classification of Pegu system	129.
———, on fire-clay of the Rajmahal Hills	39, 133.
———, on fossil fish teeth from the Pegu system	292.
———, on geology of Western Prome and Kama	259.
———, on glass sands of the Rajmahal Hills	39.
———, on the occurrence of coal at Gilhurria in the Rajmahal Hills	149.
———, on the recorrelation of Pegu system	271.
———, <i>see</i> Vredenburg, E. W.	
Students, training of	9.
Suket shales	65, 67.

SUBJECT.	Page.
Sukli	44.
Sulaik	318.
Sullivan Island	55.
Sulphate of alumina	214.
Sulphur	208, 209, 214.
Sumbaji	192.
Suru Pass	19, 34.
Surwa, fire-clay at	139, 142.
<i>Styracolheutis orientalis</i> , Crick	24.
Takatu	25, 26.
Talchirs in Kashmir	70.
Talsa, iron-ore at	41.
Tamagon beds, equivalence of, west and east of the Irrawaddy	266.
Tantalite from Western Australia	15.
Tata Sons & Co.	69.
Taungbogyi, geology of	259.
———, prospects of oil at	270.
Taungtha Hill, Pegu series of	29.
———, prospects of oil	47.
Tavoy, minerals of	56, 57, 58.
Telblhita, fire-clay at	139, 140.
<i>Telescopium fuscum</i> , Ch.	30.
Tertiary of Peninsular coast	20.
——— strata in Myitta	59.
<i>Tetrabelodon angustidens</i>	61.
<i>Tetraconodon</i> sp.	277.
Thangyi Daung	302.
Thayetmyo, <i>Ostrea latimarginata</i> in	127.
——— district, fish-teeth from	293.
Theobald, W.	11.
Thirori	44.
Tin	53, 56—59, 62.
——, production of	79.
Tin-ore, value of, produced during 1908	72.
Tipper, G. H.	5, 10, 14, 189, 205, 233.
Tipper, G. H., on fossils from Aden	336.
———, on liassic fossils of Baluchistan	25.
———, on Neocomian fossils of Baluchistan	25, 29.
———, on occurrence of samarskite in South India	341.
———, on some minerals in Baluchistan	214.

SUBJECT.	Page.
Torres Island	53.
Tourmaline	56.
<i>Tragulidae</i>	278.
Trap, absence of, on Vindhyaas	68.
Travancore State, graphite of	76.
Travancore, <i>Orbiculina</i> beds in	20.
Trias, Lower, in Kashmir	70.
<i>Trigonia costata</i>	319.
„ sp.	339.
Tucker Island	53.
Turamdih, iron-ore at	19, 41.
<i>Turritella acuticarinata</i> , Dunker	263, 265, 273.
„ <i>simplex</i> , Jenkins	263.
„ sp.	263, 264.
Tutugata, manganese at	42.
Twcen, A.	10.
Twingon	45, 48.
<i>Twingonia</i>	30, 187.
Twinza reserves, examination of the	48.
Udaipur, chlorine in rain water of	169.
Umara coal-field, output of, 1907 and 1908	74.
Umbápani, fire-clay at	139, 142.
United Provinces, dams in	39.
„, gypsum in	40.
„, licenses granted in 1908	125.
„, mineral concessions granted in	118.
„, production and value of gold in 1907 and 1908	76.
<i>Vermetus javanus</i> , K. Martin	263, 265.
<i>Vertebraria indica</i>	70.
Victoria Point	54.
Vindhyan system	62, 64, 65.
Vizagapatam, export of manganese-ore through, during 1907 and 1908	78.
Volcanic manifestations in Seistan	218.
Vredenburg, E. W.	5, 9, 10, 20, 30 65, 233, 264, 275.
„, on ammonites from the Bagh beds	20.

SUBJECT.	Page.
Vredenburg, E. W., on geology of Sarawan, Jhalawan, Mekran and Las Bela	189.
—————, on hippurite-bearing limestone in Seistan	216.
—————, on marine tertiaries of the Peninsular coast	20.
—————, on molluscan fauna of the Ranikot series	23.
—————, on <i>Nummulites Vredenburgi</i>	25.
—————, on <i>Orbitolina</i>	20.
—————, on petrology of Aden Hinterland	321.
Vredenburg, E., and Stuart, M., on the occurrence of <i>O. latimarginata</i> , Vred., in Burma	127.
Vredenburgite	17.
Wadi Tiban	314.
Wagon, cassiterite near	58.
Walker, Dr. T. L.	15.
———— H.	6, 14, 315.
Walther, J.	162.
Ward, T. R. J.	216.
Warden Island	54.
Ware, S. D.	31.
Wolfram	57, 58, 59.
Woodward, Dr. A. Smith	31.
Wyragarh	69.
Yenak Hill, iron-ore at	312.
Yenangyat, fish teeth from	293.
———— oil-field	302.
‘Yenangyaungian’	129.
Yenangyaung, fossils from	288.
————, Kama clays at	277.
————, production of petroleum, 1908	79.
———— stage	130.
————, occurrence of <i>O. latimarginata</i> in	128.
————, <i>Ostrea latimarginata</i> in	127.
Yengan-Bokpyin	56.
Yin Chaung	152, 153.
Zanskar	79.
Zewan beds.	70.
Ziaing, geology of	259.
————, prospects of oil at	270.
Zirreh Lake	217, 218.

RECORDS
OF
THE GEOLOGICAL SURVEY OF INDIA.

RECORDS*

OF

THE GEOLOGICAL SURVEY OF INDIA.

VOLUME XXXVIII.

Published by order of the Government of India.

CALCUTTA :
SOLD AT THE OFFICE OF THE GEOLOGICAL SURVEY,
27, CHOWRINGHEE ROAD.
LONDON : MESSRS. KEGAN PAUL, TRENCH, TRÜBNER & CO.
BERLIN : MESSRS. FRIEDLÄNDER UND SOHN.

1909-1910.

CONTENTS.

PART I.

	PAGES.
General Report of the Geological Survey of India for the year 1908. By SIR THOMAS H. HOLLAND, K.C.I.E., D.Sc., F.R.S.	1—70
The Mineral Production of India during 1908. By SIR THOMAS H. HOLLAND, K.C.I.E., D.Sc., F.R.S.	71—125

PART 2.

On the Occurrence of <i>Ostrea latimarginata</i> , a characteristic Gaj species, in the "Yenangyaung Stage" of Burma. By E. VREDENBURG, A.R.S.M., A.R.C.S., F.G.S., and M. STEART, B.Sc., F.G.S.	127—132
China-clay and Fire-clay Deposits in the Rajmahal Hills. By MURRAY STUART, B.Sc., F.G.S. (With Plates 1, 2 and 3, fig. 1)	133—148
The Occurrence of Coal at Gilhurria in the Rajmahal Hills. By MURRAY STUART, B.Sc., F.G.S. (With Plate 3, fig. 2)	149—151
Note on a Pegu inlier at Ondwe, Magwe District, Upper Burma. By E. H. PASCOE, M.A., B.Sc., F.G.S. (With Plates 4 and 5)	152—153
The Origin of the Salt Deposits of Rajputana. By SIR THOMAS H. HOLLAND, K.C.I.E., D.Sc., F.R.S., and W. A. K. CHRISTIE, B.Sc., PH.D. (With Plates 6 and 7)	154—186
Miscellaneous Notes	187

PART 3.

Report on the Geology of Sarawan, Jhalawan, Mckran and the State of Las Bela, considered principally from the point of view of Economic Development. By E. W. VREDENBURG. (With Plates 8 to 12)	189—215
Note on a Hippurite-bearing Limestone in Seistan and on the Geology of the adjoining Region. By ERNEST W. VREDENBURG, A.R.S.M., A.R.C.S., F.G.S. (With Plates 13 to 16)	216—229
Fusulinidae from Afghanistan. By H. H. HAYDEN, Superintendent, Geological Survey of India. (With Plates 17 to 22)	230—256
Miscellaneous Notes : Oil at Jaba	257

PART 4.

	PAGES.
Geology and Prospects of Oil in Western Prome and Kama, Lower Burma (including Namayan, Padaung, Taungbogyi and Ziaing). By MURRAY STUART, B.Sc., F.G.S. (With Plate 23)	259—270
The Recorrelation of the Pegu System in Burma with notes on the Horizon of the Oil-bearing Strata (including the Geology of Padaunkpin, Banbyin and Aukmanein). By MURRAY STUART, B.Sc., F.G.S. (With Plate 24)	271—291
Fossil Fish Teeth from the Pegu System, Burma. By MURRAY STUART, B.Sc., F.G.S. (With Plates 25 to 27)	292—301
The Northern Part of the Yenangyat Oil-field. By G. DEP. CORTER, B.A. (Dub.), F.G.S. (With Plates 28 and 29)	302—307
On some Iron-ores of Chanda, Central Provinces. By P. N. DATTA, B.Sc., Assistant Superintendent, Geological Survey of India	308—312
The Geology of the Aden Hinterland. By CAPTAIN R. E. LLOYD, M.B., D.Sc., I.M.S., late Surgeon Naturalist, Marine Survey of India. (With Plates 30 to 33)	313—320
Petrological Notes on the Rocks collected by Captain R. E. Lloyd near Aden. By E. W. VREDENBURG, A.R.S.M., A.R.C.S., F.G.S., etc. (With Plate 34).	321—335
Notes on Upper Jurassic Fossils collected by Captain R. E. Lloyd near Aden. By G. H. TIPPER, M.A., F.G.S. (With Plates 35 and 36)	336—340
Miscellaneous Notes : Samarskite in South India	341
Index	i—xxx

LIST OF PLATES, VOLUME XXXVIII.

- PLATE 1.**—Ideal section of Pátarghatta Hill by H. F. Blanford.
- PLATE 2.** Sections of borings in Pátarghatta Hill by H. F. Blanford.
- PLATE 3.**—Fig. 1.—Photograph of a 3-ft. white clay bed in Damuda white sandstone, Boraghat.
 „ 2.—Coal mine at Gilhurria.
- PLATE 4.**—Yenangyaung and Ondwe Pegu Inliers.
- PLATE 5.**—Ondwe Pegu Inlier, Magwe District, Burma.
- PLATE 6.**—Aspirator for operations in the desert.
- PLATE 7.**—Apparatus for measuring amount of salt in the air at different heights.
- PLATE 8.**—Section showing position of coal-seam at Ziarat, west of Johan.
- PLATE 9.**—Section showing position of "Laki" strata in the Shirinab Valley.
- PLATE 10.**—Section illustrating the geological structure near the Mekran Coast.
- PLATE 11.**—Diagram illustrating the position of anticlinal axes in Eastern Baluchistan and Western Sind.
- PLATE 12.**—Geological map of Eastern Baluchistan and Western Sind.
- PLATE 13.**—Geological sketch-map of Baluchistan.
- PLATE 14.**—*Hippurites gosaviensis*, Douvillé.
 Fig. 1 *a, b, c.*—Anterior, posterior and upper aspects of an almost complete lower valve.
 „ 2.—Polished surface of another lower valve.
 Both specimens from Koh-i-Nahrahu. (Natural size.)
- PLATE 15.**—*Pirontæa persica* sp. nov.
 Fig. 1.—Complete specimen with upper valve preserved.
 „ 2.—Fragment of a lower valve.
 „ 3.—Polished section of another specimen.
 All three specimens from Koh-i-Nahrahu. (Natural size.)
- PLATE 16.**—Fig. 1 *a.*—Cast of a Nerinea.
 „ 1 *b.*—Section of the same specimen.
 „ 2.—Gen. indet. spec. indet.
 Both specimens from Koh-i-Maku. (Natural size.)
- PLATE 17.**—Afghan Fusulinidæ.
 Fig. 1.—Transverse section of *Fusulina*. × 50.
 „ 2.— „ „ „ „ „ × 70.
 Figs. 3, 4.—Tangential section of shell of *F. elongata*, Shum. × 40.
 Fig. 5.—The same as lower part of fig. 4. × 90.
 „ 6.—Approximately tangential section of shell of *F. uralica*, Krotow. × 33.
 „ 7.—Part of the same enlarged. × 60.
- PLATE 18.**—Afghan Fusulinidæ.
 Fig. 1.—Transverse section of *Schwagerina princeps*, Ehr. × 50.
 „ 2.—Meridional section of *Schwagerina princeps*, Ehr. × 12.
 „ 3.—Similar section of the same species. This corresponds to *Sch. Verbeeki*, Geinitz. × 12.

PLATE 18—*contd.*

- Fig. 4.—Section of *Sch. princeps* taken at some distance from the central chamber, but approximately parallel to the axis. $\times 12$.
- .. 5.—Transverse section of *Sch. princeps* cut at some distance from the central chamber. $\times 12$.
- .. 6.—Somewhat oblique section of *Sch. princeps*. $\times 12$.
- .. 7.—Shell of *Fusulina*.

PLATE 19.—*Fusulina uralica*, Krotow.

- Figs. 1–6.—Specimens of various sizes: all natural size: fig. 4 represents a typical specimen.
- Fig. 7.—Longitudinal (meridional) section of a large specimen. $\times 4$.
- .. 8.—The same. $\times 10$.
- .. 9.—Similar section of another specimen. $\times 10$.
- Figs. 10, 11 and 12.—Transverse (equatorial) sections of typical specimens of various sizes. $\times 10$.
- Fig. 8.—Illustrates a specimen with a large central chamber.

PLATE 20.—*Fusulina elongata*, Shumard.

- Fig. 1.—Central part of a longitudinal (meridional) section of a medium-sized specimen similar to those illustrated in fig. 10. $\times 12$.
- Figs. 2–5.—Transverse (equatorial) sections of similar specimens; fig. 4 is cut at a little distance from the central chamber. $\times 12$.
- .. 6, 7.—Transverse (equatorial) sections of small specimens similar to those illustrated in fig. 11. $\times 12$.
- .. 8, 9.—Longitudinal sections of similar specimens, showing the small number of whorls. $\times 12$.
- Fig. 10.—Limestone with medium-sized specimens: natural size.
- .. 11.—Limestone with small specimens: natural size.
- Figs. 1 to 11 probably represent the megasphæric form.
- Fig. 12.—Very large specimen (? microspheric form): natural size.

PLATE 21.—Figs. 1 and 3.—Typical longitudinal (meridional) sections of *Neoschavagerina craticulifera*, Schwager. Fig. 1 $\times 15$, fig. 3 $\times 12$.

- Figs. 2 and 7.—Typical transverse (equatorial) sections of the same species. Fig. 2 $\times 15$, fig. 7 $\times 11$.
- Fig. 4.—Characteristic longitudinal section of *N. craticulifera* cut at some little distance from the central chamber. $\times 20$.
- .. 5.—Transverse section of part of the shell of *N. craticulifera*. $\times 46$.
- .. 6.—Part of a similar section enlarged to show the perforations. $\times 90$.
- .. 8.—Transverse section of *Alveolina (Flosculina) pasticillata*, Schw., from Sind. $\times 12$.

PLATE 22.—Figs. 1–4.—Longitudinal section of *Neoschavagerina primigena* nov. sp. $\times 17$.

- Fig. 5.—Transverse section of the same. $\times 20$.
- Figs. 6 and 7.—Transverse section of the same. $\times 17$.

PLATE 22—contd.

- Figs. 8, 9 and 10.—Longitudinal section of *Neoschwagerina annæ*, Volz. $\times 10$.
 Fig. 11.—Specimens shown in fig. 10 enlarged. $\times 20$.
 „ 12.—Transverse section (not through the central chamber) of *N. annæ*. $\times 23$.
 „ 13.—Transverse (equatorial) section through the central chamber of another specimen of *N. annæ*. $\times 20$.
 „ 14.—Part of a very characteristic section of *Neoschwagerina* limestone, containing *N. annæ*. $\times 12$.

PLATE 23.—Geological map of Thayetmyo District with two sections.**PLATE 24.**—Geological map of Padaukpin, Banbyin and Aukmancin.**PLATE 25.**—Figs. 1, 2, 3.—*Carcharias (Aprionodon)* sp., nat. size.

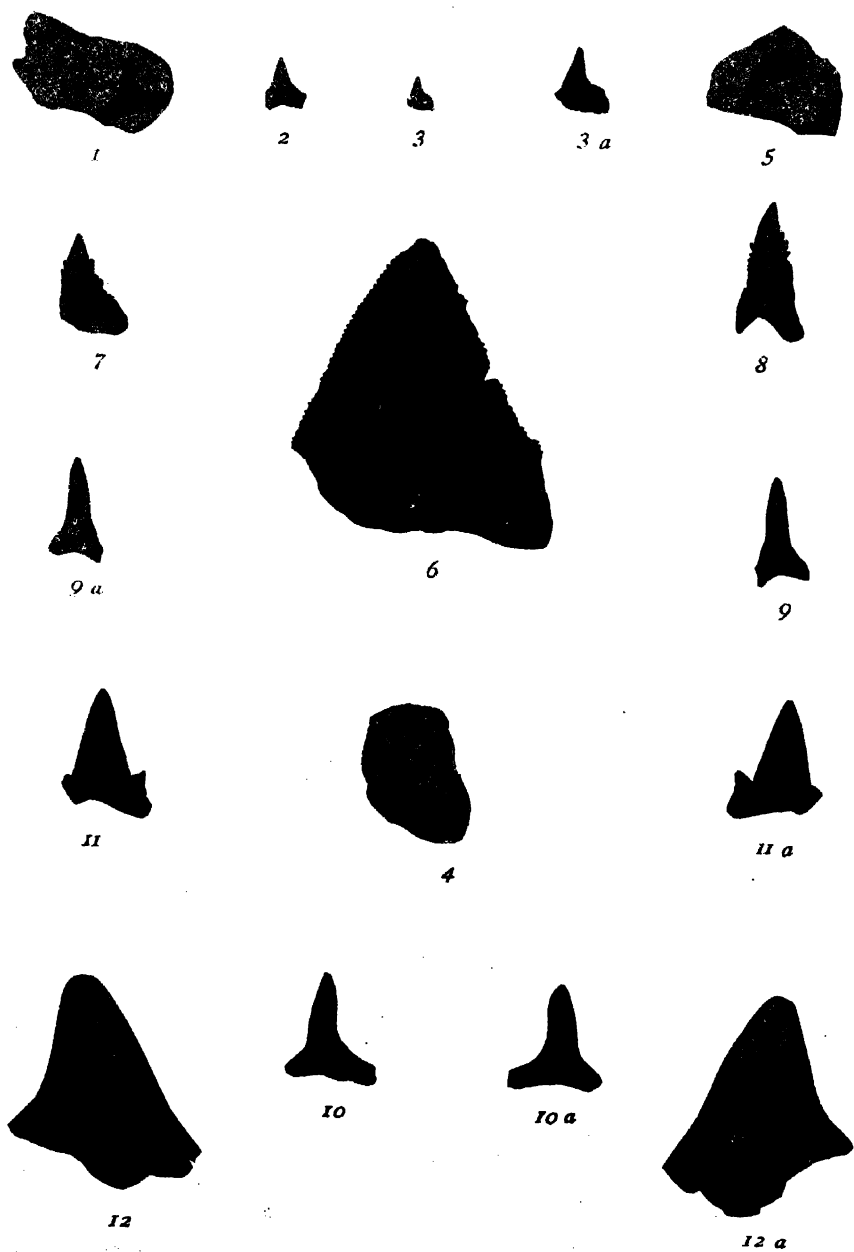
- Fig. 3 a.—Same tooth, twice natural size.
 „ 4.—*Carcharias (Prionodon)* sp., natural size.
 „ 5.—*Galeocerdo latidens*, Agassiz, natural size.
 „ 6.—*Carcharodon megalodon*, Agassiz, natural size.
 Figs. 7 and 8.—*Hemipristis serra*, Agassiz, natural size (Padaukpin).
 Fig. 9.—*Oxyrhina spallanzanii*, Bonaparte, natural size (Minbu).
 „ 9 a.—Same tooth, back view.
 „ 10.—*Oxyrhina spallanzanii*, Bonaparte, natural size (Minbu).
 „ 10 a.—Same tooth, back view.
 „ 11.—*Otodus appendiculatus*, Agassiz, natural size.
 „ 11 a.—Same tooth, back view.
 „ 12.—*Carcharodon megalotis*, Agassiz, natural size.
 „ 12 a.—Same tooth, back view.

PLATE 26.—Teeth from Singu oil-field and Pagan Hills.

- Figs. 1, 2.—*Oxyrhina spallanzanii*, Bonaparte.
 Fig. 3.—*Carcharodon angustidens*, Agassiz.
 „ 3 a.— „ „ „ (inner face).
 „ 3 b.— „ „ „ (side view).
 „ 4.—*Carcharodon lukeolatus*, Agassiz.
 „ 4 a.— „ „ „ (inner face).
 „ 4 b.— „ „ „ (side view).
 Figs. 5, 6, 7.—*Carcharias (Aprionodon) frequens*, Dames.
 Fig. 8.—*Carcharias (Prionodon) egerloni*, Ag. (inner face).
 „ 8 a.— „ „ „ (outer face).
 Figs. 9, 10, 11.—*Carcharias (Prionodon) egerloni*, Ag. (inner face).
 Fig. 12.—*Carcharias (Prionodon) collata* (ex-Cope M.S.).
 „ 12 a.— „ „ „ (inner face).
 „ 13.—*Hemipristis simplex*, n. sp. (?)
 „ 13 a.— „ „ „ (inner face).
 „ 13 b.— „ „ „ (side view).
 „ 14.—*Hemipristis serra*, Agassiz.

PLATE 27.—Fig. 1.—Vertical section of *Hemipristis simplex*, magnified sixteen diameters.**PLATE 28.**—Geological map of the northern part of the Yen angyat oil-field.

- PLATE 29.**—The northern part of the Yenangyat oil-field ; showing Pegu outcrop and position of crest with reference to blocks.
- PLATE 29a.**—Sections through the Yenangyat anticline.
- PLATE 30.**—Dala and the neighbouring hills, looking south-westward.
- PLATE 31.**—Northern half of panoramic view taken from Dala.
- PLATE 32.**—Pinnacle of massive lava surrounded by volcanic ash-beds, $\frac{1}{4}$ mile north of the Dabiyat plateau.
- PLATE 33.**—Map of a part of the hilly country to the north of Aden.
- PLATE 34.**—Upper Cretaceous volcanic rocks from Dala near Aden.
 Fig. 1.—Rhyolite.
 „ 2.—Ultra-basic lava with porphyritic crystals of olivine. $\times 20$
- PLATE 35.**—Fig. 1.—*Perisphinctes* sp. No. 2.
Parallelodon egertonianum, Stol. sp.
 „ 2.—*Perisphinctes* sp. No. 1.
Belemnites cf. *tanganensis*, Futterer.
 „ 3.—*Belemnites* cf. *tanganensis*, Futterer.
- PLATE 36.**—Figs. 1, 2, 2 a.—*Perisphinctes* sp. No. 3.
 „ 3, 4.—*Perisphinctes* sp. No. 4.
 Fig. 5.—*Pinna* sp.
 „ 6.—*Trigonic* sp. group of costatae.
 „ 7.—Gastropod. Gen. et sp. indet.



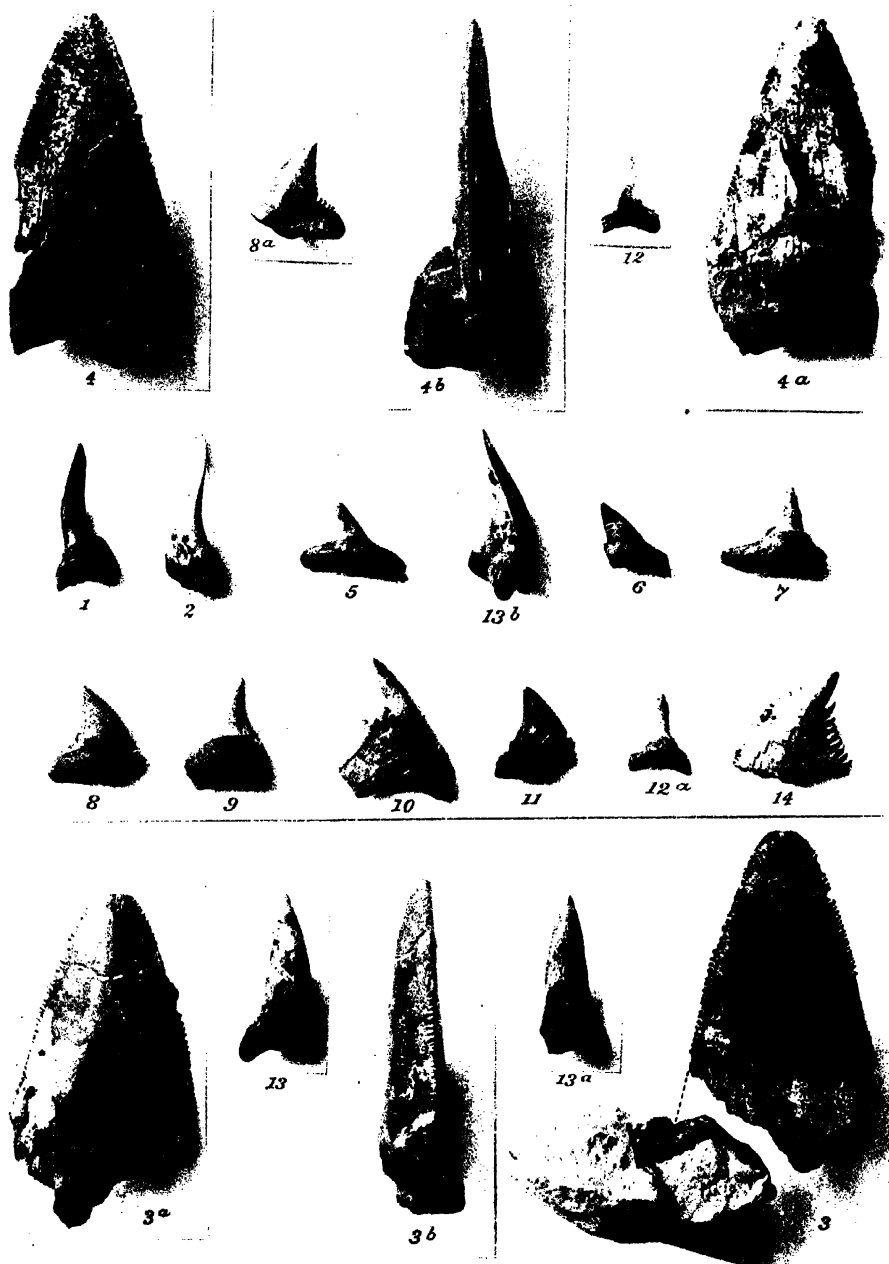


Photo. by M. Stuart

G. S. I. Calcutta

FOSSIL FISH TEETH FROM THE NEIGHBOURHOOD OF SINGU, UPPER BURMA.

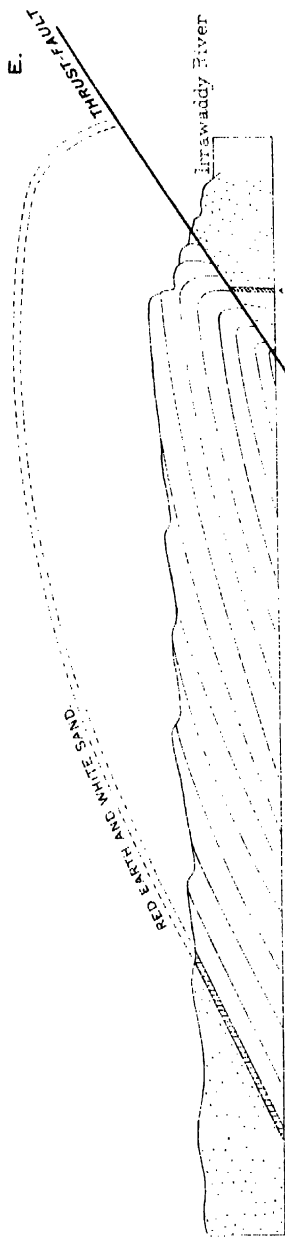


Photomicrograph by M. Stuart.

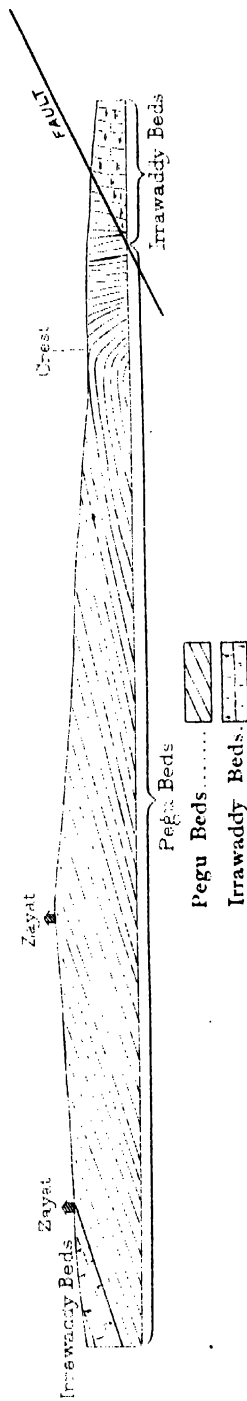
G. S. I. Calcut

VERTICAL SECTION OF HEMIPRISTIS SIMPLEX, n. sp. (?) ENLARGED 16 TIMES,

W.



HYPOTHETICAL SECTION THROUGH THE YENANGYAT ANTICLINE, TO ACCOUNT FOR THE MISSING PEGU BEDS EAST OF THE CREST OF THE ANTICLINE.



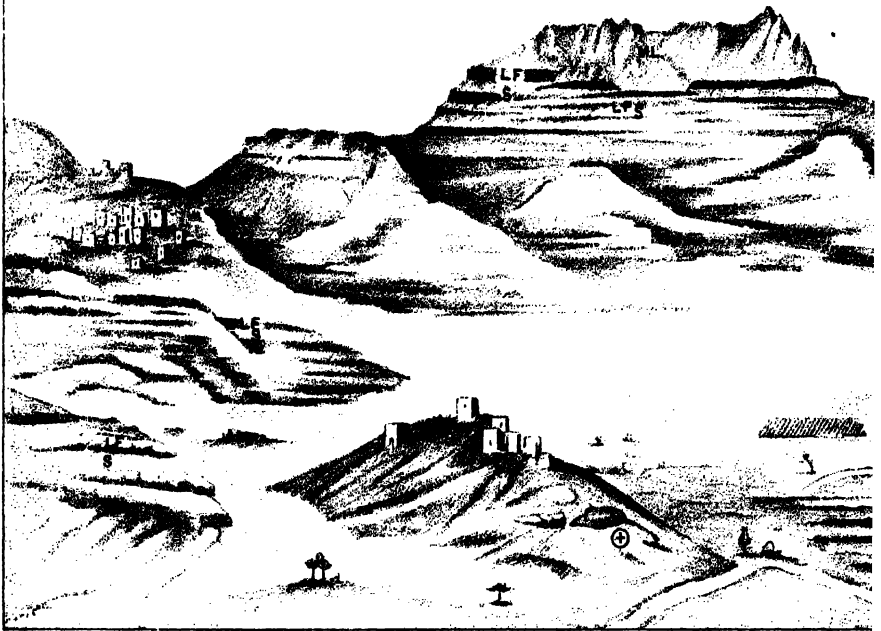
YENANGYAT ANTICLINE; SECTION ON THE SABA-LEDAING CART-ROAD.

Hor. Scale :— 2" = 1 m. : Var. Scale :— 1" = 2000 ft.

Dala.

Al. Kabar.

J. Mafari.



R. E. Lloyd del.

M L " Mas
L F Lava
A T Ashes
S Sandstone

DALA AND THE NEIGHBOURING HILLS

Camp.

J. Jihaf.



ssive lava "

flows.

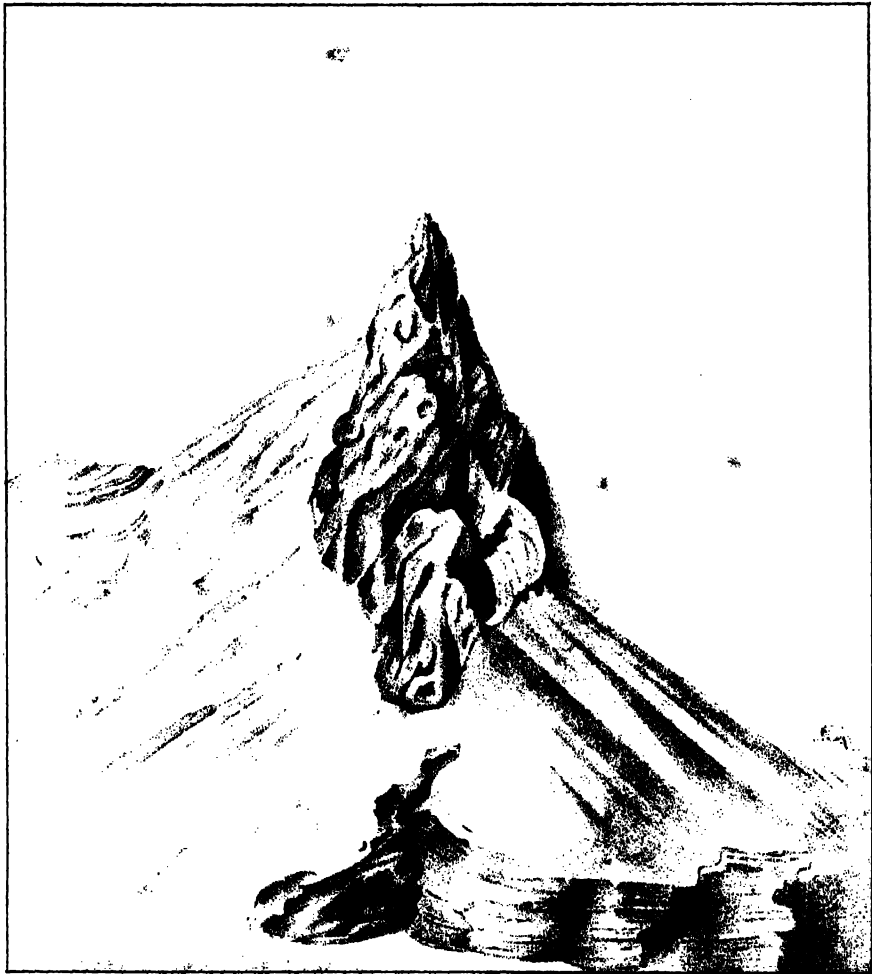
and tuffs.

stone.

LLS, LOOKING SOUTH-WESTWARD.

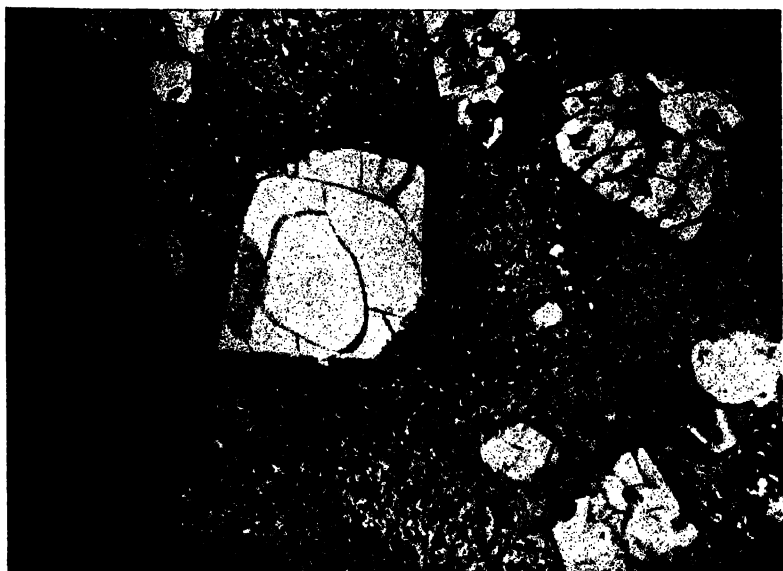
GEOLOGICAL SURVEY OF INDIA.

Records Vol. XXXVIII. Pl. 32



R. E. Lloyd del.

PINNACLE OF "MASSIVE LAVA"
SURROUNDED BY VOLCANIC ASH-BEDS,
 $\frac{1}{4}$ MILE NORTH OF THE DABIYAT PLATEAU.



E. Vredenburg Phot.

G. S. I. Calcutta.

UPPER CRETACEOUS VOLCANIC ROCKS FROM DALA NEAR ADEN.

1. Rhyolite.— 2.— Ultra-basic lava with porphyritic crystals of olivine.

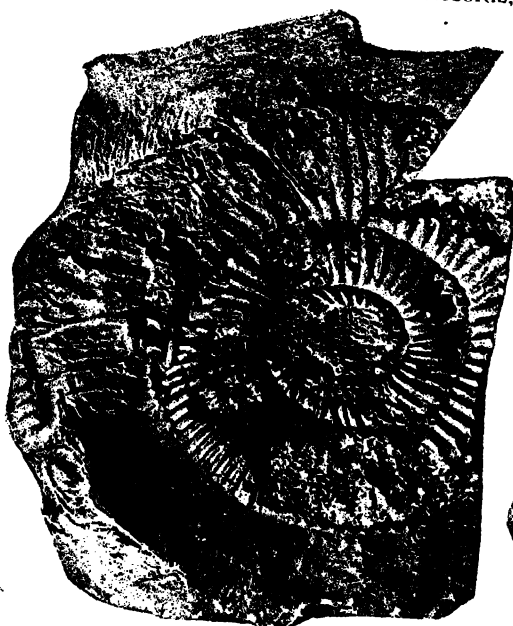


Fig. 1. $\frac{1}{1}$



Fig. 3. $\frac{2}{1}$

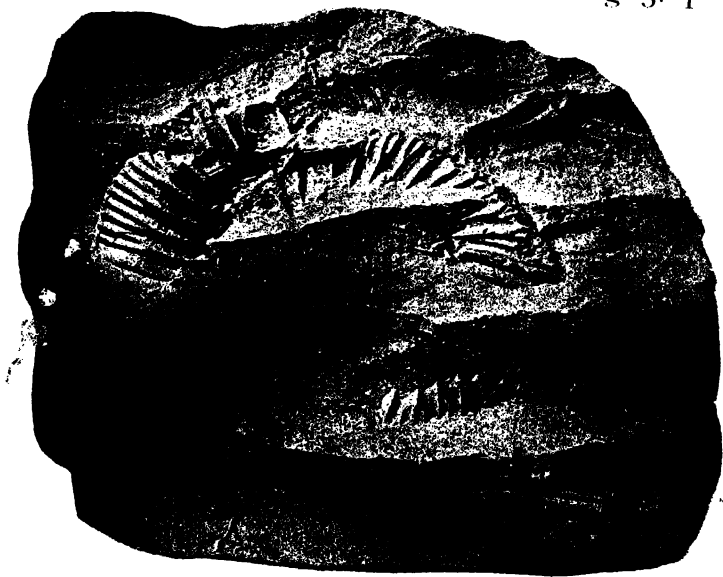


Fig 2. $\frac{1}{1}$



2 a



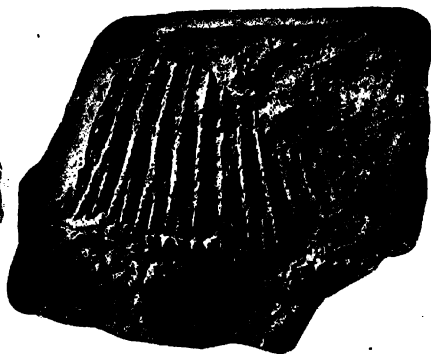
5



6



7



Natural Size

G. S. I. Calcutta.

Part 2 (out of print).—Rocks of the Lower Godavari. 'Atgarh Sandstones' near Outtack. Fossil flora in India. New or rare mammals from the Siwaliks. Arvali series in North-Eastern Rajputana. Borings for coal in India. Geology of India.

Part 3 (out of print).—Tertiary zone and underlying rocks in North-West Punjab. Fossil floras in India. Erratics in Potwar. Coal explorations in Darjiling district. Limestones in neighbourhood of Barakar. Forms of blowing-machine used by smiths of Upper Assam. Analyses of Raniganj coals.

Part 4.—Geology of Mahanadi basin and its vicinity. Diamonds, golds, and lead ores of Sambalpur district. 'Eryon Comp.' Barrovensis, McCoy, from Sripermatur group near Madras. Fossil floras in India. The Blaini group and 'Central Gneiss' in Simla Himalayas. Tertiaries of North-West Punjab. Genera *Choromeryx* and *Rhagatherium*.

VOL. XI, 1878.

Part 1.—Annual report for 1887. Geology of Upper Godavari basin, between river Wardha and Godavari, near Sironcha. Geology of Kashmir, Kishtwar, and Pangi. Siwalik mammals. Palaeontological relations of Gondwana system. 'Erratics in Punjab.

Part 2.—Geology of Sind (second notice) Origin of Kumaun lakes. Trip over Milam Pass, Kumaun. Mud volcanoes of Ramri and Cheduba. Mineral resources of Ramri, Cheduba and adjacent islands.

Part 3.—Gold industry in Wynaad. Upper Gondwana series in Trichinopoly and Nellore-Kistna districts. Senarmontite from Sarawak.

Part 4.—Geological distribution of fossil organisms in India. Submerged forest on Bombay Island.

VOL. XII, 1879.

Part 1.—Annual report for 1878. Geology of Kashmir (third notice). Siwalik mammalia. Siwalik birds. Tour through Hangiang and Spiti. Mud eruption in Ramri Island (Arakan). Braunitz, with Rhodonite, from Nagpur, Central Provinces. Palaeontological notes from Satpura coal-basin. Coal importations into India.

Part 2.—Mohpani coal-field. Pyrolusite with Psilomelane at Gosalpur, Jabalpur district. Geological reconnaissance from Indus at Kushalgarh to Kurram at Thal on Afghan frontier. Geology of Upper Punjab.

Part 3.—Geological features of northern Madura, Pudukota State, and southern parts of Tanjore and Trichinopoly districts included within limits of sheet 80 of Indian Atlas. Cretaceous fossils from Trichinopoly district, collected in 1877-78. *Sphenophyllum* and other *Equisetaceae* with reference to Indian form *Trizygia Speciosa*, Boyle (*Sphenophyllum Trizygia*, Ung.). Mysorin and Atacamite from Nellore district. *Corundum* from Khasi Hills. Joga neighbourhood and old mines on Nerbudda.

Part 4.—'Attock Slates' and their probable geological position. Marginal bone of undescribed tortoise, from Upper Siwaliks, near Nila, in Potwar, Punjab. Geology of North Arcot district. Road section from Murree to Abbottabad.

VOL. XIII, 1880.

Part 1.—Annual report for 1879. Geology of Upper Godavari basin in neighbourhood of Sironcha. Geology of Ladak and neighbouring districts. Teeth of fossil fishes from Ramri Island and Punjab. Fossil genera *Nöggerathia*, Stbg., *Nöggerathiopsis*, Falm., and *Rhiptozanites*, Schmalh., in palaeozoic and secondary rocks of Europe, Asia, and Australia. Fossil plants from Kattywai, Shekh Budin, and Sirgujah. Volcanic foci of eruption in Konkan.

Part 2.—Geological notes. Palaeontological notes on lower trias of Himalayas. Artesian wells at Pondicherry, and possibility of finding sources of water-supply at Madras.

Part 3.—Kumaun lakes. Celt of palaeolithic type in Punjab. Palaeontological notes from Karharburi and South Rewa coal-fields. Correlation of Gondwana flora with other floras. Artesian wells at Pondicherry. Salt in Rajputana. Gas and mud eruptions on Arakan coast on 12th March 1879 and in June 1883.

Part 4.—Pleistocene deposits of Northern Punjab, and evidence they afford of extreme climate during portion of that period. Useful minerals of Arvali region. Correlation of Gondwana flora with that of Australian coal-bearing system. Reh or alkali soils and saline well waters. Reh soils of Upper India. Naini Tal landslip, 18th September 1880.

VOL. XIV, 1881.

Part 1.—Annual report for 1880. Geology of part of Dardistan, Baltistan, and neighbouring districts. Siwalik carnivora. Siwalik group of Sub-Himalayan region. South Rewa Gondwana basin. Ferruginous beds associated with basaltic rocks of north eastern Ulster, in relation to Indian laterite. Rajmahal plants. Travelled blocks of the Punjab. Appendix to 'Palaeontological notes on lower trias of Himalayas.' Mammalian fossils from Perim Island.

Part 2.—Nahan Siwalik unconformity in North-Western Himalaya. Andalusite, garnets, Orthoceras beds of Hunder in Tibet. Mining records and geological notes of Great Britain and Coal and Metalliferous Mines Act of 1872 (England). Diamonds and diamonds from Khetri mines, Rajputana; with remarks on diamonds from Zimere (South-Western and Blende) with barytes in Karaul district. Eruption in island of Oheduba.

Part 3.—Artesian borings in India. Oligocene granite at Wangta on Butia, North-West Himalaya. Fish-palate from Siwalika. Palaeontological notes from Harnai and Tehardaga districts. Fossil carnivora from Siwalik hills.

Part 4.—Unification of geological nomenclature and cartography. Geology of Assam, central and eastern. Native antimony obtained at Pule Ohin, near Singapore. Emeralds from Juggiapett, Kistnah district, and zinc carbonate from Karaul, Madras. Section from Dalhousie to Pangri, via Sach Pass. South Rewah Gondwana basin. Submerged forest on Bombay Island.

VOL. XV, 1882.

Part 1 (out of print).—Annual report for 1881. Geology of North-West Kashmir and Khagan. Gondwana labyrinthodonts. Siwalik and Jainia mammas. Geology of Dalhousie, North-West Himalaya. Palm leaves from (tertiary) Murree and Kasauli beds in India. Iridomys from Noa-Dihing river, Upper Assam, and Platanus from Chulia Nagpur. On (1) copper mine near Yongri hill, Darjiling district; (2) arsenical pyrites in same neighbourhood; (3) koolia at Darjiling. Analyses of coal and fire-clay from Makum coal-field, Upper Assam. Experiments on coal of Pind Dadun Khan. Salt-range, with reference to production of gas, made April 29th, 1881. Proceedings of International Congress of Bologna.

Part 2 (out of print).—Geology of Travancore State. Warkilli beds and reported associated deposits at Quilon, in Travancore. Siwalik and Narbada fossils. Coal-bearing rocks of Upper Ber and Mand rivers in Western Chulia Nagpur. Pench river coal-field in Ohhindwara district, Central Provinces. Borings for coal at Erigenin, British Burma. Sapphires in North-Western Himalaya. Eruption of mud volcanoes in Oheduba.

Part 3.—Coal of Mach (Much) in Bolan Pass, and of Sharigh on Harnai route between Sibi and Quetta. Crystals of stilbite from Western Ghats, Bombay. Traps of Darang and Mandi in North-Western Himalaya. Connexion between Hazara and Kashmir series. Umaria coal-field (South Rewah Gondwana basin). Darangiri coal-field, Garo Hills, Assam. Coal in Myanung division, Henzada district.

Part 4 (out of print).—Gold-fields of Mysore. Borings for coal at Beddadanol, Godavari district, in 1874. Supposed occurrence of coal on Kistna.

VOL. XVI, 1883.

Part 1.—Annual report for 1882. Richthofenia, Kays (Anomia Lawrenceana, Konink). Geology of South Travancore. Geology of Chamba. Basalts of Bombay.

Part 2.—Synopsis of fossil vertebrata of India. Bijori Labyrinthodont. Skull of Hippotherium antilopinum. Iron ores, and subsidiary materials for manufacture of iron, in north-eastern part of Jabalpur district. Laterite and other manganese-ore occurring at Gosulpore, Jabalpur district. Umaria coal-field.

Part 3.—Microscopic structure of some Dalhousie rocks. Laves of Aden. Probable occurrence of Siwalik strata in China and Japan. Mastodon angustidens in India. Traverse between Almora and Mussooree. Cretaceous coal-measures at Borsota, in Khasia Hills, near Latur, in Sylhet.

Part 4.—Palaeontological notes from Dalhousie and Hutar coal-fields in Chota Nagpur. Altered basalts of Dalhousie region in North-Western Himalaya. Microscopic structure of some Sub-Himalayan rocks of tertiary age. Geology of Jannear and Lower Himalaya. Traverse through Eastern Khasia, Jaintia, and North Cachar Hills. Native lead from Maulmain and chromite from the Andaman Islands. Every eruption from one of mud volcanoes of Oheduba Island, Arakan. Irrigation from wells in North-Western Provinces and Oudh.

VOL. XVII, 1884.

Part 1.—Annual report for 1883. Simple water-embayments at mud-banks at Narrakal and Allepy on Travancore coast. Billa Surgen and other notes in Karaul district. Geology of Omapari and Simra pargana of Chamba. Eruption of Bagesh, in Kullu series of Kashmir.

Part 2.—Earthquake of 31st December 1881. Microscopic structure of some Himalayan granites and gneisses granites. Ohel and other notes in Karaul district. Notes on Siwalik beds. Mineral resources of the Andaman Islands. Notes on the Blair. Interkappan beds in Dacca and other notes on the Andaman Islands.

- Part 2 (out of print).—*Microscopic structure of some Arvali rocks. Section along Indus from Peshawar Valley to Salt-range. Sites for boring in Balgarh-Bingir coal-field (see notes). Lignite near Bapore, Central Provinces. Turquoise mines of Nishapur, Shorawan. Fiery eruptions from Mishya and volcano of Cheduba Island, Arakan. Langrin coal-field, South-Western Khasia Hills, Umeria coal-field.
- Part 3.—*Geology of part of Gangaridion pargana of British Garhwal. Slates and schists imbedded in gneissous granites of North-West Himalayas. Geology of Takht-i-Sulaiman. Smooth-water anchorages of Travancore coast. Amiferous sands of the Subansiri river. Pondicherry lignite, and phosphatic rocks at Musuri. Billa Surgam caves.

VOL. XVIII, 1885.

- Part 1.—*Annual report for 1884. Country between Singareni coal-field and Kistna river. Geological sketch of country between Singareni coal-field and Hyderabad. Coal and limestones in Deigrung river near Golaghat, Assam. Homotaxis, as illustrated from Indian formations. Afghan field notes.
- Part 2.—*Fossiliferous series in Lower Himalaya, Garhwal. Age of Mandhali series in Lower Himalaya. Siwalik camel (*Camelus Antiquus*, nobis ex Falc. and Oaut. MS). Geology of Chamba. Probability of obtaining water by means of artesian wells in plains of Upper India. Artesian sources in plains of Upper India. Geology of Aka Hills. Alleged tendency of Arakan mud volcanoes to burst into eruption most frequently during rains. Analyses of phosphatic nodules and rock from Musacore.
- Part 3.—*Geology of Andaman Islands. Third species of *Merycopotamus*. Percolation as affected by current Pirthalla and Chandpur meteorites. Oil wells and coal in Thayetnyo district, British Burma. Antimony deposits in Maulmain district. Kashmir earthquake of 30th May 1885. Bengal earthquake of 14th July 1885.
- Part 4.—*Geological work in Chhattisgarh division of Central Provinces. Bengal earthquake of 14th July 1885. Kashmir earthquake of 30th May 1885. Excavations in Billa Surgam caves. Nepaulite. Nabetmahet meteorite.

VOL. XIX, 1886.

- Part 1.—*Annual report for 1885. International Geological Congress of Berlin. Palaeozoic Fossils in Olive group of Salt-range. Correlation of Indian and Australian coal-bearing beds. Afghan and Persian Field notes. Section from Simla to Wangta, and petrological character of Amphibolites and Quartz Diorites of Sutlej valley.
- Part 2.—*Geology of parts of Bellary and Anantapur districts. Geology of Upper Dehing basin in Singhpo Hills. Microscopic characters of eruptive rocks from Central Himalayas. Mammalia of Karnul Caves. Prospects of finding coal in Western Rajputana. Olive group of Salt-range. Boulder-beds of Salt-range. Gondwana Homotaxis.
- Part 3.—*Geological sketch of Vizagapatam district, Madras. Geology of Northern Jaisalmer. Microscopic structure of Malaini rocks of Arvali region. Malanjhandi copper-ore in Balaghat district, C. P.
- Part 4 (out of print).—*Petroleum in India. Petroleum exploration at Khātan. Boring in Chhattisgarh coal-fields. Field-notes from Afghanistan: No. 3, Turkistan. Fiery eruption from one of mud volcanoes of Cheduba Island, Arakan. Nammianthal aerolite. Analysis of gold dust from Mesa valley, Upper Burma.

VOL. XX, 1887.

- Part 1.—*Annual report for 1886. Field-notes from Afghanistan: No. 4, from Turkistan to India. Physical geology of West British Garhwal; with notes on a route traversed through Jannar-Bawar and Tiri-Garhwal. Geology of Garo Hills. Indian image-stones. Soundings recently taken off Barren Island and Narcondam. Talchir boulder-beds. Analysis of phosphatic Nodules from Salt-range, Punjab.
- Part 2.—*Fossil vertebrate of India. Echinoidea of cretaceous series of Lower Narbada Valley. Field-notes: No. 5—to accompany geological sketch map of Afghanistan and North-Eastern Khorassan. Microscopic structure of Rajmahal and Deccan traps. Dolomite of Ghor. Identity of Olive series in east with speckled sandstone in west of Salt-range in Punjab.
- Part 3.—*Retirement of Mr. Medlicott. J. B. Mushketoff's Geology of Russian Turkistan. Crystalline and metamorphic rocks of Lower Himalaya, Garhwal, and Kumaun, Section I. Geology of Nanda and Jutogh. 'Lalitpur' meteorite.
- Part 4.—*Points in Himalayan geology. Crystalline and metamorphic rocks of Lower Himalaya, Garhwal, and Kumaun, Section II. Iron industry of western portion of Manipur. Notes on Upper Burma. Boring exploration in Chhattisgarh coal-fields. (Second notice). Pressure Metamorphism, with reference to foliation of Himalayan Gneiss. Papers on Himalayan Geology and Microscopic Petrology.

Vol. XXI, 1886.

- Part 1.*—Annual report for 1887. 'Crystalline and metamorphic rocks of Lower Himalayas, Garhwal, and Kumaun, Section III. Birds'-nest of Elephant Island, Mergui Archipelago. Exploration of Jessalmer, with a view to discovery of coal. Faceted pebbles from boulder bed ('speckled sandstone') of Mount Chai in Salt-range, Punjab. Nodular stones obtained off Colombo.
- Part 2.*—Award of Wollaston Gold Medal, Geological Society of London, 1888. Dharwar System in South India. Ingenuous rocks of Raipur and Balaghat, Central Provinces. Bangar Marg and Mehongale coal-fields, Kashmir.
- Part 3.*—Manganese Iron and Manganese Ores of Jabalpur. 'The Carboniferous Glacial Period.' Pre-tertiary sedimentary formations of Simla region of Lower Himalayas.
- Part 4.*—Indian fossil vertebrates. Geology of North-West Himalayas. Blown-sand rock sculpture. Nummulites in Zaskar. Mica traps from Barakar and Raniganj.

Vol. XXII, 1889.

- Part 1 (out of print)*—Annual report for 1888. Dharwar System in South India. Wajra Karur diamonds, and M. Chaper's alleged discovery of diamonds in pegmatite. Generic position of so called Plesiosaurus Indicus Flexible sandstone or Itacolomite, its nature, mode of occurrence in India, and cause of its flexibility. Siwalik and Narbada Chelonia.
- Part 2*—Indian Steatite Distorted pebbles in Siwalik conglomerate. 'Carboniferous Glacial Period' Oil fields of Twingoung and Beme, Burma Gypsum of Nehal Nadi, Kumaun. Materials for pottery in neighbourhood of Jabalpur and Umaria.
- Part 3.*—Coal outcrops in Sharigh Valley, Baluchistan. Trilobites in Neobalus beds of Salt-range. Geological notes. Cherra Poonjee coal-field, in Khasia Hills. Cobaltiferous Matt from Nepal President of Geological Society of London on International Geological Congress of 1888. Tin-mining in Mergui district.
- Part 4 (out of print)*—Land-tortoises of Siwaliks Pelvis of a ruminant from Siwaliks. Assays from Sambhar Salt Lake in Rajputana. Manganiferous iron and Manganese Ores of Jabalpur Palagonite bearing traps of Rajmahal hills and Deccan. Tin-smelting in Malay Peninsula. Provisional Index of Local Distribution of Important Minerals, Miscellaneous Minerals, Gem Stones and Quarry Stones in Indian Empire.
- Part 1.*

Vol. XXIII, 1890.

- Part 1.*—Annual report for 1889 Lakadong coal-fields, Jaintia Hills. Pectoral and pelvic girdles and skull of Indian Dacynodonts. Vertebrate remains from Nagpur district (with description of fish-skull). Crystalline and metamorphic rocks of Lower Himalayas, Garhwal and Kumaun, Section IV. Bivalves of Olive group, Salt-range. Mud banks of Travancore coasts.
- Part 2 (out of print)*—Petroleum explorations in Harnai district, Baluchistan. Sapphire Mines of Kashmir. Supposed Matrix of Diamond at Wajra Karur, Madras Sonapat Gold field. Field notes from Shan Hills (Upper Burma). New species of Syringosphaerids.
- Part 3 (out of print)*—Geology and Economic Resources of Country adjoining Sind-Pishin Railway between Sharigh and Spintangi, and of country between it and Khattan. Journey through India in 1888-89, by Dr. Johannes Walther Coal-fields of Lairungao, Maosandram, and Mao-belar-ker, in the Khasi Hills Indian Steatite. Provisional Index of Local Distribution of Important Minerals, Miscellaneous Minerals, Gem Stones, and Quarry Stones in Indian Empire.
- Part 4 (out of print)*—Geological sketch of Naini Tal; with remarks on natural conditions governing mountain slopes. Fossil Indian Bird Bones. Darjiling Coal between Lish and Ramthi rivers. Basic Eruptive Rocks of Kadappa Area. Deep Boring at Lucknow. Coal Seam or Dore Ravine, Hazara.

Vol. XXIV, 1891.

- Part 1.*—Annual report for 1890 Geology of Salt-range of Punjab, with re-considered theory of Origin and Age of Salt-Mart. Graphite in decomposed Gneiss (Laterite) in Ceylon. Glaciers of Kabru, Pandim, etc. Salts of Sambhar Lake in Rajputana, and 'Rah' from Aligarh in North-Western Provinces. Analysis of Dolomite from Salt-range, Punjab.
- Part 2.*—Oil near Moghal Kot, in Sherani country, Sulaiman Hills. Mineral Oil from Suleiman Hills. Geology of Lushai Hills. Coal-fields in Northern Shan States. Reported Nampaka Ruby-mine in Maingla State. Tourmaline (Schod) Mines in Maingla State.—Salt-spring near Hawgyo, Thibaw State.

- Part 3 (out of print).—Boring in Daltongunj Coal-field, Palamow. Death of Dr. F. Martin Duncan. Pyroxenic varieties of Gneiss and Scapolite-bearing Rocks.*
Part 4.—Mammalian Bones from Mongolia. Dyrhilling Coal Exploration. Geology and Mineral Resources of Sikkim. Rocks from the Salt-range, Punjab.

Vol. XXV, 1892.

- Part 1.—Annual report for 1891. Geology of Thal Chotiali and part of Mari country. Petrological Notes on Boulder-bed of Salt-range, Punjab. Sub-recent and Recent Deposits of valley plains of Quetta, Pishin, and Dasht-i-Bedoliat; with appendices on Chamans of Quetta; and Artesian water-supply of Quetta and Pishin.*
Part 2 (out of print).—Geology of Safed Koh. Jherria Coal-field.
Part 3.—Locality of Indian Tscheffkinite. Geological Sketch of country north of Bhamo. Economic resources of Amber and Jade mines area in Upper Burma. Iron-ores and Iron Industries of Salem District. Riebeckite in India. Coal on Great Tenasserim River, Lower Burma.
Part 4.—Oil Springs at Moghal Kot in Shirani Hills. Mineral Oil from Suleiman Hills. New Amber-like Resin in Burma. Triassic Deposits of Salt-range.

Vol. XXVI, 1893.

- Part 1.—Annual report for 1892. Central Himalayas Jadeite in Upper Burma. Burmite, new Fossil Resin from Upper Burma. Prospecting Operations, Mergui District, 1891-92.*
Part 2.—Earthquake in Baluchistan on 20th December 1892. Burmite, new amber-like fossil resin from Upper Burma. Alluvial deposits and Subterranean water-supply of Rangoon.
Part 3.—Geology of Sherani Hills. Carboniferous Fossils from Tenasserim. Boring at Chandernagore. Granite in Tavoy and Mergui.
Part 4.—Geology of country between Chappar Rift and Harnai in Baluchistan. Geology of part of Tenasserim Valley with special reference to Tendau-Kamapying Coal field. Magnetite containing Manganese and Alumina. Hialopite.

Vol. XXVII, 1894.

- Part 1.—Annual report for 1893. Bhaganwala Coal-field, Salt-range, Punjab.*
Part 2.—Petroleum from Burma. Singareni Coal-field, Hyderabad (Deccan). Gohna Landslip, Garhwal.
Part 3.—Cambrian Formation of Eastern Salt-range. Giridih (Karharbari) Coal-fields Chipped (?) Flints in Upper Miocene of Burma. Velates Schmideliana, Chemn., and Provelates grandis, Sow. sp. in Tertiary Formation of India and Burma.
Part 4.—Geology of Wuntho in Upper Burma. Echinoids from Upper Cretaceous System of Baluchistan. Highly Phosphatic Mica Peridotites intrusive in Lower Gondwana Rocks of Bengal. Mica-Hypersthene-Hornblende Peridotite in Bengal.

Vol. XXVIII, 1895.

- Part 1.—Annual report for 1894. Cretaceous Formation of Pondicherry. Early allusion to Barren Island. Bibliography of Barren Island and Narcondam from 1884 to 1894.*
Part 2.—Cretaceous Rocks of Southern India and geographical conditions during later cretaceous times. Experimental Boring for Petroleum at Sukkur from October 1893 to March 1895. Tertiary system in Burma.
Part 3.—Jadeite and other rocks, from Tamaw in Upper Burma. Geology of Techi Valley. Lower Gondwanas in Argentina.
Part 4.—Igneous Rocks of Giridih (Kurbaree) Coal-field and their Contact Effects. Vindhyan system south of Sone and their relation to so-called Lower Vindhyan. Lower Vindhyan area of Sone Valley. Tertiary system in Burma.

Vol. XXIX, 1896.

- Part 1.—Annual report for 1895. Acicular inclusions in Indian Garnets. Origin and Growth of Garnets and of their Micropegmatitic intergrowths in Pyroxenic rocks.*
Part 2.—Ultra-basic rocks and derived minerals of Chalk (Magnesite) hills, and other localities near Salem, Madras. Corundum localities in Salem and Coimbatore districts, Madras. Corundum and Kyanite in Manbhumi district, Bengal. Ancient Geography of "Gondwanaland." Notes.
Part 3.—Igneous Rocks from the Techi Valley. Notes.
Part 4.—Scaevite mines, Mishin district, Burma. Lower Vindhyan (Sub-Kaimur) area of Sone Valley, Rewah. Notes.

Vol. XXX, 1897.

- Part 1.*—Annual report for 1896. Norite and associated Basic Dykes and Lava-flows in Southern India. Genus *Vertebraria*. On *Glossopteris* and *Vertebraria*.
Part 2.—Cretaceous Deposits of Pondicherry. Notes.
Part 3.—Flow structure in igneous dykes. Olivine-norite dykes at Coonoor. Excavations for corundum near Palakod, Salem District. Occurrence of coal at Palana in Bikanir. Geological specimens collected by Afghan-Baluch Boundary Commission of 1896.
Part 4.—Nematite from Afghanistan. Quartz-barytes rock in Salem District, Madras Presidency. Worn femur of *Hippopotamus iravadicus*, Caut. and Falc., from Lower Pliocene of Burma. Supposed coal at Jaintia, Baxa Duars. Percussion Figures on micas. Notes.

Vol. XXXI, 1904.

- Part 1 (out of print)*—Prefatory Notice Copper-ore near Komai, Darjeeling district. Zewan beds in Vihri district, Kashmir. Coal deposits of Isa Khel, Mianwali district, Punjab. Um-Rilong coal-beds, Assam. Sapphirine-bearing rock from Vizagapatam district. Miscellaneous Notes. Assays.
Part 2 (out of print)—Lt.-Genl. C. A. McMahon. Cyclobus Haydeni Diener. Auriferous Occurrences of Chota Nagpur, Bengal. On the feasibility of introducing modern methods of Coke-making at East Indian Railway Collieries, with supplementary note by Director, Geological Survey of India. Miscellaneous Notes.
Part 3 (out of print)—Upper Palaeozoic formations of Eurasia. Glaciation and History of Sind Valley. Halorites in Trias of Baluchistan. Geology and Mineral Resources of Mayurbhanj. Miscellaneous Notes.
Part 4 (out of print)—Geology of Upper Assam. Auriferous Occurrences of Assam. Curious occurrence of Scapolite from Madras Presidency. Miscellaneous Notes. Index.

Vol. XXXII, 1905.

- Part 1 (out of print)*—Review of Mineral Production of India during 1898—1903.
Part 2 (out of print)—General report, April 1903 to December 1904. Geology of Provinces of Tsang and U in Tibet. Bauxite in India. Miscellaneous Notes.
Part 3 (out of print)—Anthracolithic Fauna from Subansiri Gorge, Assam. Elephas Antiquus (Namadicus) in Godavari Alluvium. Triassic Fauna of Tropites-Limestones of Byans. Amblygonite in Kashmir. Miscellaneous Notes
Part 4.—Obituary notices of H. B. Medlicott and W. T. Blanford. Kangra Earthquake of 4th April 1905. Index to Volume XXXII.

Vol. XXXIII, 1906.

- Part 1 (out of print)*—Mineral Production of India during 1904. Pleistocene Movement in Indian Peninsula. Recent Changes in Course of Nam-tu River, Northern Shan States. Natural Bridge in Gokteik Gorge. Geology and Mineral Resources of Narnaul District (Patiala State). Miscellaneous Notes.
Part 2 (out of print)—General report for 1905. Lashio Coal-field, Northern Shan States. Namma, Mansang and Man-se-le Coalfields, Northern Shan States, Burma. Miscellaneous Notes.
Part 3 (out of print)—Petrology and Manganese-ore Deposits of Sausar Tahsil, Ohhindwara district, Central Provinces. Geology of part of valley of Kanhan River in Nagpur and Ohhindwara districts, Central Provinces. Manganite from Sandur Hills. Miscellaneous Notes.
Part 4 (out of print)—Composition and Quality of Indian Coals. Classification of the Vindhyan System. Geology of State of Panna with reference to the Diamond-bearing Deposits. Index to Volume XXXIII.

Vol. XXXIV, 1906.

- Part 1.*—Fossils from Halorites Limestone of Bambanag Cliff, Kumaon. Upper-Triassic Fauna from Pishin District, Baluchistan. Geology of portion of Bhutan. Coal Occurrences in Foot-hills of Bhutan. Dandli Coal-field: Coal outcrops in Kotli Tehsil of Jammu State. Miscellaneous Notes.
Part 2 (out of print)—Mineral Production of India during 1905. Nummulites Douvillei, with remarks on Zonal Distribution of Indian Nummulites. Auriferous Tracts in Southern India. Abandonment of Collieries at Warora, Central Provinces. Miscellaneous Notes.
Part 3—Explosion Craters in Lower Chindwin district, Burma. Lavas of Pavagad Hill. Gibbsite with Manganese-ore from Talevadi, Belgaum district, and Gibbsite from Bhekowli, Satar District. Classification of Tertiary System in Sind with reference to Zonal distribution of Eocene Echinoidea.

Part 4 (out of print).—Jaipur and Nazira Coal-fields, Upper Assam. Makum Coal-fields between Tirap and Namdang Streams. Kabat Anticline, near Seiktein, Myingyan district, Upper Burma. Asymmetry of Yenangyat-Singü Anticline, Upper Burma. Northern part of Gwegyo Anticline, Myingyan District, Upper Burma. Breyzia Multituberculata, from Nari of Baluchistan and Sind. Index to Volume XXXIV.

VOL. XXXV, 1907.

Part 1 (out of print).—General report for 1906. Orthophragmina and Lepidocyclina in Nummulitic Series. Meteoric Shower of 22nd October 1903 at Dokachi and neighbourhood, Dacca District.

Part 2.—Indian Aerolites. Brine-wells at Bawgyo, Northern Shan States. Gold-bearing Deposits of Loi Twang, Shan States. Physa Prinsepia in Maastrichtian strata of Baluchistan. Miscellaneous Notes.

Part 3.—Preliminary survey of certain Glaciers in North-West Himalaya. A.—Notes on certain Glaciers in North-West Kashmir.

Part 4.—Preliminary survey of certain Glaciers in North-West Himalaya. B.—Notes on certain Glaciers in Lahaul. C.—Notes on certain Glaciers in Kumaon. Index to Volume XXXV.

VOL. XXXVI, 1907-08.

Part 1.—Petrological Study of Rocks from hill tracts, Vizagapatam district, Madras Presidency. Nepheline Syenites from hill tracts, Vizagapatam district, Madras Presidency. Stratigraphical Position of Gangamopteris Beds of Kashmir. Volcanic outburst of Late Tertiary Age in South Hsenwi, N. Shan States. New snails from Bugti Hills, Baluchistan. Permo-Carboniferous Plants from Kashmir.

Part 2 (out of print).—Mineral Production of India during 1906. Ammonites of Bagh Beds. Miscellaneous Notes.

Part 3.—Marine fossils in Yenangyaung oil-field, Upper Burma. Fresh-water shells of genus Batissa in Yenangyaung oil-field, Upper Burma. New Species of Dendrophyllia from Upper Miocene of Burma. Structure and age of Taungtha hills, Myingyan district, Upper Burma. Fossils from Sedimentary rocks of Oman (Arabia). Rubies in Kachin hills, Upper Burma. Cretaceous Orbitoides of India. Two Calcutta Earthquakes of 1906. Miscellaneous Notes

Part 4.—Pseudo-Fucoids from Pah sandstones at Fort Munro, and from Vindhyan series. Jadeite in Kachin Hills, Upper Burma. Wetchok Yedwet Pegu outcrop, Magwe district, Upper Burma. Group of Manganates, comprising Hollandite, Psilomelane and Coronadite. Occurrence of Wolfram in Nagpur district, Central Provinces. Miscellaneous Notes Index to Volume XXXVI

VOL. XXXVII, 1908-09.

Part 1.—General report for 1907. Mineral Production of India during 1907 Occurrence of striated boulders in Blaini formation of Simla. Miscellaneous Notes.

Part 2.—Tertiary and Post-Tertiary Freshwater Deposits of Baluchistan and Sind. Geology and Mineral Resources of Rajpipla State. Suitability of sands in Rajmahal Hills for glass manufacture. Three new Manganese-bearing minerals:—Vredenburgite, Sitaparite and Juddite. Laterites from Central Provinces. Miscellaneous Notes.

Part 3.—Southern part of Gwegyo Hills, including Payagygon-Ngashandaung Oil field. Silver-lead mines of Bawdwin, Northern Shan States. Mud volcanoes of Arakan Coast, Burma.

Part 4.—Gypsum Deposits in Hamirpur district, United Provinces. Gondwana and related marine sedimentary system of Kashmir Miscellaneous Notes Index to Volume XXXVII.

VOL. XXXVIII, 1909.

Part 1—General report for 1908 Mineral Production of India during 1908

Part 2.—Ostrea latimarginata in Burma China clay and Fire-clay of Rajmahal Hills. Coal at Gilhurria. Pegu Indier at Ondwe Salt Deposits of Rajputana. Miscellaneous Notes.

Part 3—Geology of Sarawan, Jhalawan and Las Bela. Hippurite limestone in Seistan. Afgan Fusulinidæ. Miscellaneous Notes.

The price fixed for the publications is 1 rupee (1s 4d.) each part, or 2 rupees (2s. 8d.) each volume of four part

MISCELLANEOUS PUBLICATIONS.

- Manual of the Geology of India.** 4 Vols. With map 1879-1887—
 Vol. 1. Peninsular Area. } By H. B. Medlicott and W. T. Blanford
 Vol. 2. Extra Peninsular Area. } (out of print).
 Vol. 3. Economic Geology. By V. Ball (out of print).
 Vol. 4. Mineralogy. By F. R. Mallet. Price 2 rupees.
A Manual of the Geology of India, 2nd edition. By R. D. Oldham (1893). Price 6 rupees.
A Manual of Geology of India, Economic Geology, by the late Prof. V. Ball, 2nd edition, revised in parts.
 Part I.—Corundum. By T. H. Holland (1898). Price 1 rupee.
Popular guides to the Geological collections in the Indian Museum, Calcutta—
 No. 1. Tertiary vertebrate animals. By R. Lydekker (1879) (out of print).
 No. 2. Minerals. By F. R. Mallet (1879) (out of print).
 No. 3. By F. Fedden (1880) (out of print).
 No. 4. Palaeontological collections. By O. Feistmantel (1881). Price 2 annas.
 No. 5. Economic mineral products. By F. R. Mallet (1883) (out of print).
An introduction of the Chemical and Physical study of Indian Minerals. By T. H. Holland (1895) (out of print).
Catalogue of the remains of Siwalik Vertebrata contained in the Geological Department of the Indian Museum. By R. Lydekker, Pt. I. Mammalia (1885). Price 1 rupee.
 Pt. II. Aves, Reptilia, and Pisces (1886). Price 4 annas.
Catalogue of the remains of Pleistocene and Pre-Historic Vertebrata contained in the Geological Department of the Indian Museum. By R. Lydekker (1886). Price 4 annas.
Bibliography of Indian Geology. By R. D. Oldham (1888). Price 1 rupee 8 annas.
Report on the geological structure and stability of the hill slopes around Naini Tal. By T. H. Holland (1897). Price 3 rupees.
Geological map of India, 1893. Scale 1"=96 miles (out of print).
General Report for the period from 1st January 1897 to the 1st April 1898 Price 1 rupee.
General Report for the year 1898-99 (out of print).
General Report for the year 1899-1900. Price 1 rupee.
General Report for the year 1900-1901. Price 1 rupee.
General Report for the year 1901-1902. Price 1 rupee.
General Report for the year 1902-1903. Price 1 rupee.
Contents and index to Records, Vols I-XX and Vols. XXI-XXX. Price 1 rupee each
Contents and index to Memoirs, 1859-1883 (First twenty volumes). Price 1 rupee

GEOLOGICAL SURVEY OF INDIA.

Director.

SIR THOMAS H. HOLLAND, K.C.I.E., D.Sc., F.R.S., A.R.C.S., F.G.S.

Superintendents.

TOM. D. LATOUCHE, B.A. (Cantab.), F.G.S. : C. S. MIDDLEMISS, B.A. (Cantab.) F.G.S. :
 H. H. HAYDEN, B.A., B.E. (T.C.D.), F.G.S.

Assistant Superintendents.

P. N. DATTA, B.Sc. (London) :
 E. W. VREDENBURG, B.L., B.Sc. (France), A.R.S.M., A.R.C.S., F.G.S. :
 L. LEIGH FERMOR, A.R.S.M., D.Sc. (London), F.G.S. :
 GUY E. PILGRIM, D.Sc. (London), F.G.S. : G. H. TYPPEL, M.A. (Cantab.), F.G.S. :
 H. WALKER, A.R.C.S., F.G.S., A.Inst.M.M. :
 E. H. PARSONS, M.A. (Cantab.), B.Sc. (London), F.G.S. :
 K. A. K. HALLOWES, B.A. (Cantab.), A.R.S.M., F.G.S., A. Inst. M.M. :
 G. DE P. COTTER, B.A. (Dub.) :
 J. COGGIN BROWN, B.Sc. (Dunelm), F.G.S., F.C.S. :
 J. J. A. PAGE, A.R.S.M., A.I.M.M. (London) :
 H. C. JONES, A.R.S.M., A.R.C.S., F.G.S. : A. M. HERON, B.Sc. (Edin.), F.G.S. :
 M. STUART, B.Sc. (Birmingham), F.G.S. :
 N. D. DARU, B.Sc., B.A. (Bom.), B.Sc. (London), A.R.S.M., Bar.-at-law.

Chemist.

W. A. K. CHRISTIE, B.Sc. (Edin.), Ph.D.

Sub-Assistants.

* S. SETHU RAMA RAU, B.A. : M. VINAYAK RAO, B.A.

Artist.

H. B. W. GARRICK.

Assistant Curator.

T. R. BLITH.

Registrar.

A. E. MACAULAY ADDSEY, F.Z.S.

Geological Museum, Library, and Office, Calcutta.

- Part 3.*—Maskat and Massandim on east coast of Arabia. Example of local jointing. Axial group of Western Proma. Geology of Bombay Presidency.
- Part 4.*—Coal in northern region of Satpura basin. Evidence afforded by raised oyster banks on coasts of India, in estimating amount of elevation indicated thereby. Possible field of coal-measures in Godavari district, Madras Presidency. Lameta or intratrappean formation of Central India. Petroleum localities in Pegu. Supposed eoconial limestone of Yellam Billa.

VOL. VI, 1873.

- Part 1.*—Annual report for 1872. Geology of North-West Provinces.
- Part 2.*—Bisrampur coal-field. Mineralogical notes on gneiss of south Mirzapur and adjoining country.
- Part 3.*—Calt in ossiferous deposits of Narbada valley (Pliocene of Falconer): on age of deposits, and on associated shells. Barakars (coal-measures) in Beddadanole field, Godavari district. Geology of parts of Upper Punjab. Coal in India. Salt-springs of Pegu.
- Part 4.*—Iron deposits of Chanda (Central Provinces). Barren Islands and Narkondam. Metalliferous resources of British Burma.

VOL. VII, 1874.

- Part 1 (out of print).*—Annual report for 1873. Hill ranges between Indus valley in Ladak and Shah-i-Dula on frontier of Yarkand territory. Iron ores of Kumaon. Raw materials for iron-smelting in Raniganj field. Elastic sandstone, or so-called Itacolymyte. Geological notes on part of Northern Hazaribagh.
- Part 2 (out of print).*—Geological notes on route traversed by Yarkand Embassy from Shah-i-Dula to Yarkand and Kashgar. Jade in Karakas valley, Turkistan. Notes from Eastern Himalaya. Petroleum in Assam. Coal in Garo Hills. Copper in Narbada valley. Potash salt from East India. Geology of neighbourhood of Mari hill station in Punjab.
- Part 3.*—Geological observations made on a visit to Chaderkul, Thian Shan range. Former extension of glaciers within Kangra district. Building and ornamental stones of India. Materials for iron manufacture in Raniganj coal-field. Manganese-ore in Wardha coal-field.
- Part 4 (out of print).*—Auriferous rocks of Dhambal hills, Dharwar district. Antiquity of human race in India. Coal recently discovered in the country of Luni Pathans, south-east corner of Afghanistan. Progress of geological investigation in Godavari district, Madras Presidency. Subsidiary materials for artificial fuel.

VOL. VIII, 1875.

- Part 1.*—Annual report for 1874. The Altum-Artush considered from geological point of view. Evidences of 'ground-ice' in tropical India, during Talcir period. Trials of Raniganj fire-bricks.
- Part 2 (out of print).*—Gold-fields of south-east Wynaad, Madras Presidency. Geological notes on Khareean hills in Upper Punjab. Water-bearing strata of Surat district. Geology of Scindia's territories.
- Part 3 (out of print).*—Shahpur coal-field, with notice of coal explorations in Narbada region. Coal recently found near Mofiong, Khasia Hills.
- Part 4 (out of print).*—Geology of Nepal. Raigarh and Hingir coal-fields.

VOL. IX, 1876.

- Part 1 (out of print).*—Annual report for 1875. Geology of Sind.
- Part 2.*—Retirement of Dr. Oldham. Age of some fossil floras in India. Cranium of *Stegodon* Ganessa, with notes on sub genus and allied forms. Sub Himalayan series in Jammu (Jammoo) Hills.
- Part 3.*—Fossil floras in India. Geological age of certain groups comprised in Gondwana series of India, and on evidence they afford of distinct zoological and botanical terrestrial regions in ancient epochs. Relations of fossiliferous strata at Maleri and Kota, near Sironcha, O. P. Fossil mammalian fauna of India and Burma.
- Part 4.*—Fossil floras in India. Osteology of *Merycopotamus dissimilis*. Addenda and Corrigenda to paper on tertiary mammalia. *Plesiosaurus* in India. Geology of Pir Panjal and neighbouring districts.

VOL. X, 1877.

- Part 1.*—Annual report for 1876. Geological notes on Great Indian Desert between Sind and Rajputana. Cretaceous genus *Omphalia* near Namcho lake, Tibet, about 75 miles north of Lhasa. *Estheria* in Gondwana formation. Vertebrata from Indian tertiary and secondary rocks. New Emydine from the upper tertiaries of Northern Punjab. Observations on under-ground temperature.

RECORDS OF THE GEOLOGICAL SURVEY OF INDIA.

VOL. I, 1868.

- Part 1 (out of print).*—Annual report for 1867. Coal-seams of Tawa valley. Coal in Garrow Hills. Copper in Bundelkund. Meteorites.
- Part 2 (out of print).*—Coal-seams of neighbourhood of Chanda. Coal near Nagpur. Geological notes on Surat collectorate. Cephalopodous fauna of South Indian cretaceous deposits. Lead in Raipur district. Coal in Eastern Hemisphere. Meteorites.
- Part 3 (out of print).*—Gastropodous fauna of South Indian cretaceous deposits. Notes on route from Poona to Nagpur *via* Ahmednuggur, Jalna, Loonar, Yeotmal, Mangali and Hingunghat. Agate-flake in pliocene (?) deposits of Upper Godavery. Boundary of Vindhyan series in Rajputana. Meteorites.

VOL. II, 1869.

- Part 1 (out of print).*—Valley of Poorna river, West Berar. Kuddapah and Kurnool formations. Geological sketch of Shillong plateau. Gold in Singhboom, etc. Wells at Hazareebagh. Meteorites.
- Part 2.*—Annual report for 1868. Pangshura tecta and other species of *Chelonia* from newer tertiary deposits of Nerbudda valley. Metamorphic rocks of Bengal.
- Part 3.*—Geology of Kuch, Western India. Geology and physical geography of Nicobar Islands.
- Part 4 (out of print).*—Beds containing silicified wood in Eastern Prome, British Burma. Mineralogical statistics of Kumaon division. Coal-field near Chanda. Lead in Raipur district. Meteorites.

VOL. III, 1870.

- Part 1.*—Annual report for 1869. Geology of neighbourhood of Madras. Alluvial deposits of Irrawadi, contrasted with those of Ganges.
- Part 2 (out of print).*—Geology of Gwalior and vicinity. Slates at Chitoli, Kumaon. Lead vein near Chicholi, Raipur district. Wardha river coal-fields, Berar and Central Provinces. Coal at Karba in Bilaspur district.
- Part 3 (out of print).*—Mohpani coal-field. Lead-ore at Slimanabad, Jabalpur district. Coal east of Chhattingarh between Bilaspur and Ranchi. Petroleum in Burma. Petroleum locality of Sudkal, near Futtyjung, west of Rawalpindi. Argentiferous galena and copper in Manbhum. Assays of iron ores.
- Part 4 (out of print).*—Geology of Mount Tilla, Punjab. Copper deposits of Dalbhum and Singbhum : 1.—Copper mines of Singbhum : 2.—Copper of Dalbhum and Singbhum. Meteorites.

VOL. IV, 1871.

- Part 1.*—Annual report for 1870. Alleged discovery of coal near Gooty, and of indications of coal in Cuddapah district. Mineral statistics of Kumaon division.
- Part 2.*—Axial group in Western Prome. Geological structure of Southern Konkan. Supposed occurrence of native antimony in the Straits Settlements. Deposit in boilers of steam-engines at Raniganj. Plant-bearing sandstones of Godavari valley, on southern extensions of Kamthi group to neighbourhood of Ellore and Rajamandri, and on possible occurrence of coal in same direction.
- Part 3.*—Borings for coal in Godavari valley near Dumagudem and Bhadrachalam. Narbada coal-basin. Geology of Central Provinces. Plant-bearing sandstones of Godavari valley.
- Part 4.*—Ammonite fauna of Kutch. Raigur and Hengir (Gangpur) Coal-field. Sandstones in neighbourhood of first barrier on Godavari, and in country between Godavari and Ellore.

VOL. V, 1872.

- Part 1.*—Annual report for 1871. Relations of rocks near Murree (Mari), Punjab. Mineralogical notes on gneiss of South Mirzapur and adjoining country. Sandstones in neighbourhood of first barrier on Godavari, and in country between Godavari and Ellore.
- Part 2.*—Coasts of Baluchistan and Persia from Karachi to head of Persian Gulf, and some of Gulf Islands. Parts of Kummummet and Hanamoonde districts in Nizam's Dominions. Geology of Orissa. New coal-field in south-eastern Hyderabad (Deccan) territory.

- Upper Triassic Cephalopoda Fauna of the Himalaya : Vol. III, pt. 1 (1899), by Dr. E. von Mojsisovics, pp. 157, pls. 22.
- Trias Brachiopoda and Lamellibranchiata : Vol. III, pt. 2 (1899), by Alexander Bittner, pp. 76, pls. 12 (2 double).
- The Fauna of the Spiti Shales : Vol. IV, Pt. 1, Fasc. 1 (1903), pp. 132, pls. 18; Fasc. 2 (1910), pp. 133-306, pls. 47 (2 double). By Dr. V. Uhlig.
- The Fauna of the Tropites-Limestone of Byans : Vol. V, Memoir No. 1 (1906), by Dr. C. Diener, pp. 201, pls. 17 (1 double).
- The Fauna of the Hima'yan Muschelkalk : Vol. V, Memoir No. 2 (1907), by Dr. C. Diener, pp. 140, pls. 17 (2 double).
- Ladinic, Carnic and Noric faunas of Spiti : Vol. V, Memoir No. 3 (1908), by Dr. C. Diener, pp. 167, pls. 24 (3 double).
- Lower-Triassic Cephalopoda from Spiti, Malla Johar and Byans : Vol. VI, Memoir No. 1 (1909), by Drs. A. von Krafft and C. Diener, pp. 186, pls. 31.
- The Fauna of the Traumatocrinus Limestone of Painkhanda : Vol. VI, Memoir No. 2 (1909), by Dr. C. Diener, pp. 39, pls. 5.
- The Cambrian Fossil of Spiti : Vol. VII, Memoir No. 1 (1910), pp. 70, pls. 6, by F. R. C. Reed.
- The Ordovician and Silurian fossils from the Central Himalaya : Vol. VII, Memoir No. 2 (*in the Press*), by F. R. C. Reed.

(SER. XVI.)—BALUCHISTAN FOSSILS, by FRITZ NOETTLING, Ph.D., F.G.S.
 The Fauna of the Kellaways of Mazâr Drik : Vol. I, pt. 1 (1895), pp. 22, pls. 13.
 The Fauna of the (Neocomian) Belemnite Beds : Vol. I, pt. 2 (1897), pp. 6, pls. 2.
 The Fauna of the Upper Cretaceous Maëstrichtien Beds of the Mari Hills : Vol. I, pt. 3 (1897), pp. 79, pls. 23.

(NEW SERIES.)

- The Cambrian Fauna of the Eastern Salt-range : Vol. I, Memoir 1 (1899), K. Redlich, pp. 14, pl. 1.
- Notes on the Morphology of the Pelecypoda : Vol. I, Memoir 2 (1899), Fritz Noetting, pp. 58, pls. 4.
- Fauna of the Miocene Beds of Burma : Vol. I, Memoir 3 (1901), Fritz Noetting, pp. 378, pls. 25 (*out of print*).
- Observations sur quelques Plantes Fossiles des Lower Gondwanas : Vol. II, Memoir 1 (1902), R. Zeiller, pp. 39, pls. 7.
- Permo-Carboniferous (Lower Gondwana) Plants and Vertebrates from Kashmir : (1) Plants, by A. C. Seward; (2) Fishes and Labyrinthodonts, by A. Smith Woodward : Vol. II, Memoir No. 2 (1905), pp. 13, pls. 3.
- The Lower Palaeozoic Fossils of the Northern Shan States, Upper Burma : Vol. II, Memoir No. 3 (1906), by F. R. C. Reed, pp. 154, pls. 8.
- The Fauna of the Napeng Beds or the Rhætic Beds of Upper Burma : Vol. II, Memoir No. 4 (1908), by Miss M. Healey, pp. 88, pls. 9.
- The Devonian Faunas of the Northern Shan States : Vol. II, Memoir No. 5 (1908), by F. R. C. Reed, pp. 183, pls. 20.
- The Mollusca of the Ranikot Series : Vol. III, Pt. 1, Memoir No. 1 (1909), pp. xix, 83, pls. 8, by M. Cossmann and G. Pissarro. Introduction, by E. W. Vredenburg.
- On some Fish-remains from the Beds at Dongargaon, Central Provinces : Vol. III, Memoir No. 3 (1908), by A. Smith Woodward, pp. 6, pl. 1.
- The Fossil Giraffidae of India : Vol. III, Memoir No. 4 (*in the Press*), by G. E. Pilgrim.

The price fixed for these publications is four annas (4 pence) per single plate, with a minimum charge of Re. 1..

- Vol. III, pp. xiv, 264, pls. 38. 1884-86.** Pt. 1; Additional Siwalik Perissodactyla and Proboscidea. Pt. 2; Siwalik and Narbada Bunodont Suina. Pt. 3; Rodents and new Ruminants from the Siwaliks. Pt. 4; Siwalik Birds. Pt. 5; Mastodon Teeth from Perim Island. Pt. 6; Siwalik and Narbada Chelonia. Pt. 7; Siwalik Orocoidia, Lacertilia and Ophidia. Pt. 8; Tertiary Fishes.
- Vol. IV, pt. 1, 1886.** Siwalik Mammalia (Supplement 1); pp. 18, pls. 6.
- Vol. IV, pt. 2, 1886.** The Fauna of the Kawnul caves (and addendum to pt. 1); pp. 40 (19-68), pls. 5 (vii-xi).
- Vol. IV, pt. 3, 1887.** Eocene Chelonia from the Salt-range; pp. 7 (59-65), pls. 2 (xii-xlii).

(SER. VII, XIV.)—TERTIARY AND UPPER CRETACEOUS FAUNA OF WESTERN INDIA, by P. MARTIN DUNCAN and W. PERCY SLADEN, except Pt. 1, by F. STOLICZKA.

- Vol. I, pp. 16+110+382+91=599, pls. 5+28+58+13=104. 1871-85.** Pt. 1: Tertiary Crabs from Sind and Kach. Pt. 1 (new 2): Sind Fossil Corals and Alcyonaria; by P. Martin Duncan. Pt. 3: The Fossil Echinoidea of Sind: *Fas. 1*, The *Cardita beaumonti* beds; *Fas. 2*, The Ranikot Series in Western Sind; *Fas. 3*, The Khirthar Series; *Fas. 4*, The Nari (Oligocene) Series; *Fas. 5*, the Gaj (Miocene) Series; *Fas. 6*, The Makran (Pliocene) Series; by Duncan and Sladen. Pt. 4: The Fossil Echinoidea of Kach and Kattywar, by Duncan, Sladen and Blanford.

(SER. XIII.)—SALT-RANGE FOSSILS, by WILLIAM WAAGEN, PH.D.

- Productus-Limestone Group: Vol. I, pt. 1 (1879).** Pisces, Cephalopoda, pp. 72, pls. 6.
- " " " " " 2 (1880). Gastropoda and supplement to pt. 1, pp. 111 (73-183), pls. 10 (1 double), (vii-xvi).
- " " " " " 3 (1881). Pelecypoda, pp. 144 (185-328), pls. 8 (xvii-xxiv).
- " " " " " 4 (1882-85). Brachiopoda, pp. 442 (329-770), pls. 62 (xxv-lxxxvi).
- " " " " " 5 (1885). Bryozoa-Annelidæ-Echinodermata, pp. 64 (771-834), pls. 10 (lxxxvii-xcvi).
- " " " " " 6 (1886). Coelenterata, pp. 90 (835-924), pls. 20 (xcvii-cxvi).
- " " " " " 7 (1887). Coelenterata, Protozoa, pp. 74 (925-998), pls. 12 (cxvii-cxxviii).
- Fossils from the Ceratite Formation: Vol. II, pt. 1 (1895).** Pisces-Ammonoides, pp. 324, pls. 40.
- Geological Results: Vol. IV, pt. 1 (1889), pp. 1-88, pls. 4 (out of print).**
- " " " " " 2 (1891), pp. 89-242, pls. 8 (out of print).

(SER. XV.)—HIMALAYAN FOSSILS.

- Upper-triassic and liassic faunas of the exotic blocks of Malla Johar in the Bhot Mahale of Kumaon: Vol. I, pt. 1 (1908), by Dr. C. Diener, pp. 100, pls. 16 (1 double).**
- Anthracolithic Fossils of Kashmir and Spiti: Vol. I, pt. 2 (1899), by Dr. C. Diener, pp. 96, pls. 8.**
- The Permocarboniferous Fauna of Chitichun No. I: Vol. I, pt. 3 (1897), by Dr. C. Diener, pp. 105, pls. 13.**
- The Permian Fossils of the Productus Shales of Kumaon and Garhwal: Vol. I, pt. 4 (1897), by Dr. C. Diener, pp. 54, pls. 5.**
- The Permian Fossils of the Central Himalayas: Vol. I, pt. 5 (1903), by Dr. C. Diener, pp. 204, pls. 10.**
- The Cephalopoda of the Lower Trias: Vol. II, pt. 1 (1897), by Dr. C. Diener, pp. 182, pls. 23.**
- The Cephalopoda of the Muschelkalk: Vol. II, pt. 2 (1895), by Dr. C. Diener, pp. 118, pls. 31.**

PALÆONTOLOGIA INDICA.

(SER. I, III, V, VI, VIII.)—CRETACEOUS FAUNA OF SOUTHERN INDIA, by
F. STOLICZKA, *except* Vol. I, Pt. 1, by H. F. BLANFORD.

- SER. I & III.—VOL. I. The Cephalopoda (1861-65), pp. 216, pls. 84 (6 double).
V.—VOL. II. The Gastropoda (1867-68), pp. xiii, 500, pls. 28.
VI.—VOL. III. The Pelecypoda (1870-71), pp. xxii, 537, pls. 50.
VIII.—VOL. IV. The Brachiopoda, Ciliopoda, Echinodermata, Corals, etc. (1872-73), pp. v, 202, pls. 29.

(SER. II, XI, XII.)—THE FOSSIL FLORA OF THE GONDWANA SYSTEM, by
O. FEISTMANTEL, *except* Vol. I, Pt. 1, by T. OLDHAM and J. MORRIS.

- VOL. I, pp. xviii, 233, pls. 72. 1863-79. Pt. 1; Rájmahál Group, Rájmahál Hills, Pt. 2; *The same (continued)*. Pt. 3; Plants from Golapili. Pt. 4; Outliers on the Madras Coast.
VOL. II, pp. xli, 115, pls. 26. 1876-78. Pt. 1; Jurassic Flora of Kach. Pt. 2: Flora of the Jabalpur Group.
VOL. III, pp. xi, 64+149, pls. 80 (9 double) (I—XXXI+IA—XLVIIA). 1879-81. Pt. 1; The Flora of the Talchur-Karharbari beds. Pt. 2; The Flora of the Damuda and Panchet Divisions. Pt. 3; *The same (concluded)*.
VOL. IV, pp. xxvi, 25+66, pls. 35 (2 double) (I—XXI+IA—XIVA). Pt. 1 (1882); Fossil Flora of the South Rewah Gondwana basin. Pt. 2 (1886); Fossil Flora of some of the coal-fields in Western Bengal.

(SER. IX.)—JURASSIC FAUNA OF KACH.

- VOL. I (1873-76). The Cephalopoda, by W. WAAGEN, pp. i, 247, pls. 60 (6 double).
VOL. II, pt. 1 (1893). The Echinoides of Kach, by J. W. GREGORY, pp. 12, pls. 2.
VOL. II, pt. 2 (1900). The Corals, by J. W. GREGORY, pp. 196, i—IX, pls. 26.
VOL. III, pt. 1 (1900). The Brachiopoda, by F. L. KITCHIN, pp. 87, pls. 15.
VOL. III, pt. 2 (1903). Lamellibranchiata: Genus Trigonina, by F. L. KITCHIN, pp. 122, pls. 10 (*out of print*).

(SER. IV.)—INDIAN PRE-TERTIARY VERTEBRATA.

- VOL. I, pp. vi, 137, pls. 26. 1865-85. Pt. 1 (1865); the Vertebrate Fossils from the Panchet rocks, by T. H. HUXLEY. Pt. 2 (1878); The Vertebrate Fossils of the Kota-Maleri Group, by SIR P. DE M. GRAY EGBERTON, L. O. MIALLE, and W. T. BLANFORD. Pt. 3 (1879); Reptilia and Batrachia, by R. LYDEKKER. Pt. 4 (1885); The Labyrinthodont from the Bijori group, by R. LYDEKKER (*out of print*). Pt. 5 (1885); The Reptilia and Amphibia of the Maleri and Denwa groups, by R. LYDEKKER (*out of print*).

(SER. X.)—INDIAN TERTIARY AND POST-TERTIARY VERTEBRATA, by
R. LYDEKKER, *except* Vol. I, Pt. 1, by R. B. FOOTE.

- VOL. I, pp. xxx, 300, pls. 50. 1874-80. Pt. 1; Rhinoceros deccanensis. Pt. 2; Molar teeth and other remains of Mammalia. Pt. 3; Crania of Ruminants. Pt. 4; Supplement to Pt. 3. Pt. 5; Siwalik and Narbada Proboscidea.
VOL. II, pp. xv, 363, pls. 45. 1881-84. Pt. 1; Siwalik Rhinocerotidae. Pt. 2; Supplement to Siwalik and Narbada Proboscidea. Pt. 3; Siwalik and Narbada Equidae. Pt. 4; Siwalik Camelopardalidae. Pt. 5; Siwalik Selenodont Suina, etc. Pt. 6; Siwalik and Narbada Carnivora.

- VOL. XVIII.** Pt. 1, 1881 (*price 2 Rs.*): Southern Afghanistan. Pt. 2, 1881 (*out of print*): Mámbhum and Singbhum. Pt. 3, 1881 (*price 2 Rs.*): Fránhita, Godávári Valley.
- VOL. XIX.** Pt. 1, 1882 (*price 2 Rs.*): Cachar Earthquake of 1868. Pt. 2, 1882 (*price 1 Rs.*): Thermal Springs of India. Pt. 3, 1883 (*price 1 Rs.*): Catalogue of Midian Earthquakes. Pt. 4, 1883 (*out of print*): Geology of parts of Manipar and Nága Hills.
- VOL. XX.** Pt. 1, 1883 (*out of print*): Geology of Madura and Tinnevely. Pt. 2, 1883 (*out of print*): Geological notes on Hills in neighbourhood of Sind and Punjab-Frontier between Quetta and Dera Ghazi Khan.
- VOL. XXI.** Pt. 1, 1884 (*out of print*): Geology of Lower Narbada Valley. Pt. 2, 1884 (*out of print*): Geology of Kathiawar. Pt. 3, 1885 (*out of print*): Coal-field of South Rewah. Pt. 4, 1885 (*out of print*): Barren Island.
- VOL. XXII.** 1883 (*price 5 Rs.*): Geology of Kashmir, Chamba, and Khagan.
- VOL. XXIII.** 1891 (*price 5 Rs.*): Geology of Central Himalayas.
- VOL. XXIV.** Pt. 1, 1887 (*out of print*): Southern Coal-fields of Sátúra Gondwána basin. Pt. 2, 1890 (*out of print*): Geology of Sub-Himalaya of Garhwal and Kumaun. Pt. 3, 1890 (*out of print*): Geology of South Malabar, between Baypore and Ponnáni Rivers.
- VOL. XXV.** 1896 (*out of print*): Geology of Bellary District, Madras Presidency.
- VOL. XXVI.** 1896 (*out of print*): Geology of Hazara.
- VOL. XXVII.** Pt. 1, 1895 (*out of print*): Marine Fossils from Miocene of Upper Burma. Pt. 2, 1897 (*out of print*): Petroleum in Burma and its technical exploitation.
- VOL. XXVIII.** Pt. 1, 1898 (*price 2 Rs.*): Geological Structure of Chitichun region.—Allahbund in north-west of Rann of Kuchh.—Geology of parts of Myingyan, Magwè and Pakokkn Districts, Burma—Geology of Mikir Hills in Assam—Geology of Tirah and Bazár Valley. Pt. 2, 1900 (*price 3 Rs.*): Charnockite Series, group of Archean Hypersthenic Rocks in Peninsular India.
- VOL. XXIX.** 1900 (*price 5 Rs.*): Earthquake of 12th June 1897.
- VOL. XXX.** Pt. 1, 1900 (*price 2 Rs.*): Aftershocks of Great Earthquake of 12th June 1897. Pt. 2, 1900 (*price 1 Rs.*): Geology of neighbourhood of Salem, Madras Presidency. Pt. 3, 1901 (*price 1 Rs.*): Sivamalai Series of Elæolite-Syenites and Corundum Syenites. Pt. 4, 1901 (*price 1 Rs.*): Geological Congress of Paris.
- VOL. XXXI.** Pt. 1, 1901 (*price 2 Rs.*): Geology of Son Valley in Rewah State and of Parts of Jabalpur and Mirzapur. Pt. 2, 1901 (*price 3 Rs.*): Baluchistan Desert and part of Eastern Persia. Pt. 3, 1901 (*price 1 Rs.*): Peridotites, Serpentes, etc., from Ladakh.
- VOL. XXXII.** Pt. 1, 1901 (*price 1 Rs.*): Recent Artesian Experiments in India. Pt. 2, 1901 (*price 2 Rs.*): Rampur Coal-field. Pt. 3, 1902 (*price 3 Rs.*): "Exotic Blocks" of Malla Johar in Bhot Mahals of Kumaon. Pt. 4, 1904 (*price 3 Rs.*): Jammu Coal-fields.
- VOL. XXXIII.** Pt. 1, 1901 (*price 8 Rs.*): Kolar Gold-field. Pt. 2, 1901 (*price 2 Rs.*): Art. 1: Gold-fields of Wainád. Art. 2: Auriferous Quartzites of Parhadiah, Chota Nagpur. Art. 3: Auriferous localities in North Coimbatore. Pt. 3, 1902 (*price 1 Rs.*): Geology of Kalahandi State, Central Provinces.
- VOL. XXXIV.** Pt. 1, 1901 (*price 1 Rs.*): Peculiar form of altered peridotite in Mysore State. Pt. 2, 1902 (*price 3 Rs.*): Mica deposits of India. Pt. 3, 1903 (*price 1 Rs.*): Sandhills of Clifton near Karachi. Pt. 4, 1908 (*price 4 Rs.*): Geology of Persian Gulf and adjoining portions of Persia and Arabia.
- VOL. XXXV.** Pt. 1, 1902 (*price 2 Rs.*): Geology of Western Rajputana. Pt. 2, 1903 (*price 1 Rs.*): Aftershocks of Great Earthquake of 12th June 1897. Pt. 3, 1904 (*price 1 Rs.*): Seismic phenomena in British India and their connection with its Geology. Pt. 4 (*in the Press*): Geology of Andaman Islands, with references to Nicobars.
- VOL. XXXVI.** Pt. 1, 1904 (*price 4 Rs.*): Geology of Spiti. Pt. 2, 1907 (*price 3 Rs.*): Geology of Provinces of Tsang and Ü in Central Tibet. Pt. 3 (*in the Press*): Trias of the Himalayas.
- VOL. XXXVII.** 1909. Manganese-Ore Deposits of India: Pt. 1 (*price 3 Rs.*), Introduction and Mineralogy; Pt. 2 (*price 3 Rs.*), Geology; Pt. 3 (*price 3 Rs.*), Economics and Mining; Pt. 4 (*price 5 Rs.*), Description of Deposits.
- VOL. XXXVIII.** 1910 (*price 5 Rs.*): Kangra Earthquake of 4th April 1905.

MEMOIRS OF THE GEOLOGICAL SURVEY OF INDIA.

- VOL.** I. Pt. 1, 1856 (*out of print*) : Coal and Iron of Talchir.—Talchir Coal-field.—Gold-yielding deposits of Upper Assam.—Gold from Shub-gween. Pt. 2, 1858 (*out of print*) : Geological structure of a portion of Khasi Hills.—Geological structure of Nilgiri Hills (Madras). Pt. 3, 1859 (*out of print*) : Geological structure and physical features of districts of Bankura, Midnapore, and Orissa.—Laterite of Orissa.—Fossil fish-teeth of genus *Ceratodus*, from Maledi, south of Nagpur.
- VOL.** II. Pt. 1, 1860 (*out of print*) : Vindhyan rocks, and their associates in Bundelkand. Pt. 2, 1860 (*out of print*) : Geological structure of central portion of Nerbudda District.—Tertiary and alluvial deposits of central portion of Nerbudda Valley.—Geological relations and probable age of systems of rocks in Central India and Bengal.
- VOL.** III. Pt. 1, 1863 (*out of print*) : Raniganj Coal-field.—Additional remarks on systems of rocks in Central India and Bengal.—Indian Mineral Statistics, I. Coal. Pt. 2, 1864 (*out of print*) : Sub-Himalayan Ranges between Ganges and Ravi.
- VOL.** IV. Pt. 1, 1863 (*out of print*) : Cretaceous Rocks of Trichinopoly District, Madras. Pt. 2, 1864 (*out of print*) : Districts of Trichinopoly, Salem, etc. Pt. 3, 1865 (*out of print*) : Coal of Assam, etc.
- VOL.** V. Pt. 1, 1865 (*out of print*) : Sections across N.-W. Himalaya, from Sutlej to Indus.—Gypsum of Spiti. Pt. 2, 1866 (*out of print*) : Geology of Bombay. Pt. 3, 1866 (*out of print*) : Jheria Coal-field.—Geological Observations on Western Tibet.
- VOL.** VI. Pt. 1, 1867 (*out of print*) : Neighbourhood of Lynyan, etc., in Sind.—Geology of portion of Cutch. Pt. 2, 1867, Rep. 1908 (*price* 2 Rs.) : Bokaro Coal-field.—Ramgarh Coal-field.—Traps of Western and Central India. Pt. 3, 1869 (*price* 2 Rs. 8 As.) : Tapti and Nerbudda Valleys.—Frog-beds in Bombay.—*Oxyglossus pusillus*.
- VOL.** VII. Pt. 1, 1869 (*price* 3 Rs.) : Vindhyan series.—Mineral Statistics.—Coal.—Shillong Plateau. Pt. 2, 1870 (*out of print*) : Karharbári Coal-field.—Deoghhar Coal-field. Pt. 3, 1871 (*out of print*) : Aden water-supply.—Karaupura Coal-fields.
- VOL.** VIII. Pt. 1, 1872 (*price* 4 Rs.) : Kadapah and Karnul Formations in Madras Presidency. Pt. 2, 1872 (*price* 1 Rs.) : Itkhuri Coal-field.—Daltonganj Coal-field.—Chope Coal-field.
- VOL.** IX. Pt. 1, 1872 (*out of print*) : Geology of Kutch. Pt. 2, 1872 (*price* 1 Rs.) : Geology of Nagpur.—Geology of Sirban Hill.—Carboniferous Ammonites.
- VOL.** Pt. 1 (*price* 3 Rs.) : Geology of Madras.—Sátpura Coal-basin. Pt. 2, 1874 (*price* 2 Rs.) : Geology of Pegu.
- VOL.** XI. Pt. 1, 1874 (*price* 2 Rs.) : Geology of Dárrjiling and Western Duars. Pt. 2, 1876 (*price* 3 Rs.) : Salt-region of Kohát, Trans-Indus.
- VOL.** XII. Pt. 1, 1877 (*price* 3 Rs.) : South Máhrátta Country. Pt. 2, 1876 (*price* 2 Rs.) : Coal-fields of Nága Hills.
- VOL.** XIII. Pt. 1, 1877 (*price* 2 Rs. 8 As.) : Wardha Valley Coal-field. Pt. 2, 1877 (*price* 2 Rs. 8 As.) : Geology of Rájmahál Hills.
- VOL.** XIV. 1878 (*price* 5 Rs.) : Geology of Salt-range in Punjab.
- VOL.** XV. Pt. 1, 1878 (*price* 2 Rs. 8 As.) : Auranga and Hutár Coal-fields (Palamow). Pt. 2, 1880 (*price* 2 Rs. 8 As.) : Ramkola and Tatapani Coal-fields (Sirguja).
- VOL.** XVI. Pt. 1, 1878 (*price* 1 Rs. 8 As.) : Geology of Eastern Coast from Lat. 15° to Masulipatam. Pt. 2, 1880 (*price* 1 Rs. 8 As.) : Nellore Portion of Carnatic. Pt. 3, 1880 (*price* 2 Rs.) : Coastal Region of Godávari District.
- VOL.** XVII. Pt. 1, 1879 (*price* 3 Rs.) : Geology of Western Sind. Pt. 2, 1880 (*price* 2 Rs.) : Trans-Indus extension of Punjab Salt-range.

RECORDS OF THE GEOLOGICAL SURVEY OF INDIA.

VOL. XL, PART I.

1910.

CONTENTS.

	PAGES.
Pre-Carboniferous Life-Provinces. By F. R. Cowper Reed, M.A., F.G.S.	1-35
Lakes of the Salt Range in the Punjab. By T. D. La Touche, B.A., F.G.S., Officiating Director, Geological Survey of India (with Plates 1 to 14)	36-51
A Preliminary Survey of certain Glaciers in the Himalaya. By Officers of the Geological Survey of India (continued from Records, Volume XXXV, Part 4).	
D.—Notes on Certain Glaciers in Sikkim. By T. H. D. LaTouche, B.A., F.G.S., Officiating Director, Geological Survey of India (with Plates 15 to 27)	52-62
Notices of new Mammalian Genera and Species from the Tertiaries of India. By Guy E. Pilgrim, D.Sc., F.G.S., Assistant Superintendent, Geological Survey of India.	63-71

Published by order of the Government of India.

CALCUTTA:

SOLD AT THE OFFICE OF THE GEOLOGICAL SURVEY,
27, CHOWRINGHEE ROAD.

LONDON: MESSRS. KEGAN PAUL, TRENCH TRÜBNER & CO.,
BERLIN: MESSRS. FRIEDLÄNDER UND SOHN.

1910

Printed and Bound by the Government of India, at the Government Press, Calcutta.

RECORDS

THE GEOLOGICAL SURVEY OF INDIA.

VOL. XL, PART II.

1910.

CONTENTS.

	PAGES.
General Report of the Geological Survey of India for the year 1909. By T. H. D. LaTouche, B.A., F.G.S., Officiating Director, Geological Survey of India . . .	73—122
The Mineral Production of India during 1909. By T. H. D. LaTouche, B.A., F.G.S., Officiating Director, Geological Survey of India	123—184

Published by order of the Government of India.

CALCUTTA :

**SOLD AT THE OFFICE OF THE GEOLOGICAL SURVEY,
27, CHOWRINGHEE ROAD.**

**LONDON : MESSRS. KEGAN PAUL, TRENCH TRÜBNER & CO.,
BERLIN : MESSRS. FRIEDLÄNDER UND SOHN.**

1910

Sales One Rupee per Part, or Two Rupees per Volume of 2 Parts.

MEMOIRS OF THE GEOLOGICAL SURVEY OF INDIA.

- VOL.** I. Pt. 1, 1856 (*out of print*): Coal and Iron of Talchir.—Talchir Coal-field.—Gold-yielding deposits of Upper Assam.—Gold from Shné-gween. Pt. 2, 1858 (*out of print*): Geological structure of a portion of Khasi Hills.—Geological structure of Nilgiri Hills (Madras). Pt. 3, 1859 (*out of print*): Geological structure and physical features of districts of Bankura, Midnapore, and Orissa.—Laterite of Orissa.—Fossil fish-teeth of genus *Ceratodus*, from Maledi, south of Nagpur.
- VOL.** II. Pt. 1, 1860 (*out of print*): Vindhyan rocks, and their associates in Bundelkand. Pt. 2, 1860 (*out of print*): Geological structure of central portion of Nerbudda District.—Tertiary and alluvial deposits of central portion of Nerbudda Valley.—Geological relations and probable age of systems of rocks in Central India and Bengal.
- VOL.** III. Pt. 1, 1863 (*out of print*): Raniganj Coal-field.—Additional remarks on systems of rocks in Central India and Bengal.—Indian Mineral Statistics, I. Coal. Pt. 2, 1864 (*out of print*): Sub-Himalayan Ranges between Ganges and Ravi.
- VOL.** IV. Pt. 1, 1863 (*out of print*): Cretaceous Rocks of Trichinopoly District, Madras. Pt. 2, 1864 (*out of print*): Districts of Trichinopoly, Salem, etc. Pt. 3, 1865 (*out of print*): Coal of Assam, etc.
- VOL.** V. Pt. 1, 1865 (*out of print*): Sections across N.-W. Himálāya, from Sutlej to Indus.—Gypsum of Spiti. Pt. 2, 1866 (*out of print*): Geology of Bombay. Pt. 3, 1866 (*out of print*): Jheria Coal-field.—Geological Observations on Western Tibet.
- VOL.** VI. Pt. 1, 1867 (*out of print*): Neighbourhood of Lynyan, etc., in Sind.—Geology of portion of Cutch. Pt. 2, 1867, Rep. 1908 (*price* 2 Rs.): Bokáro Coal-field.—Ramgarh Coal-field.—Traps of Western and Central India. Pt. 3, 1869 (*price* 2 Rs. 8 As.): Tapti and Nerbudda Valleys.—Frog-beds in Bombay.—*Oxyglossus pusillus*.
- VOL.** VII. Pt. 1, 1869 (*price* 3 Rs.): Vindhyan series.—Mineral Statistics.—Coal.—Shillong Plateau. Pt. 2, 1870 (*out of print*): Karharbári Coal-field.—Deoghar Coal-field. Pt. 3, 1871 (*out of print*): Aden water-supply.—Kārapura Coal-fields.
- VOL.** VIII. Pt. 1, 1872 (*price* 4 Rs.): Kadapah and Karnul Formations in Madras Presidency. Pt. 2, 1872 (*price* 1 Rs.): Itkhuri Coal-field.—Daltonganj Coal-field.—Chope Coal-field.
- VOL.** IX. Pt. 1, 1872 (*out of print*): Geology of Kutch. Pt. 2, 1872 (*price* 1 Rs.): Geology of Nagpur.—Geology of Sirban Hill.—Carboniferous Ammonites.
- VOL.** X. Pt. 1 (*price* 3 Rs.): Geology of Madras.—Sátpura Coal-basin. Pt. 2, 1874 (*price* 2 Rs.): Geology of Pegu.
- VOL.** XI. Pt. 1, 1874 (*price* 2 Rs.): Geology of Dárjiling and Western Duars. Pt. 2, 1876 (*price* 3 Rs.): Salt-region of Kohát, Trans-Indus.
- VOL.** XII. Pt. 1, 1877 (*price* 3 Rs.): South Mahrátta Country. Pt. 2, 1876 (*price* 2 Rs.): Coal-fields of Nága Hills.
- VOL.** XIII. Pt. 1, 1877 (*price* 2 Rs. 8 As.): Wardha Valley Coal-field. Pt. 2, 1877 (*price* 2 Rs. 8 As.): Geology of Rájmahál Hills.
- VOL.** XIV. 1878 (*price* 5 Rs.): Geology of Salt-range in Punjab.
- VOL.** XV. Pt. 1, 1878 (*price* 2 Rs. 8 As.): Aurunga and Hutár Coal-fields (Palamow). Pt. 2, 1880 (*price* 2 Rs. 8 As.): Ramkola and Tatapani Coal-fields.
- VOL.** XVI. Pt. 1, 1879 (*price* 1 Rs. 8 As.): Geology of Eastern Coast from Lat. 16° to Manulipatam. Pt. 2, 1880 (*price* 1 Rs. 8 As.): Nellore Portion of Carnatic. Pt. 3, 1880 (*price* 2 Rs.): Coastal Region of Godávari District.
- VOL.** XVII. Pt. 1, 1879 (*price* 3 Rs.): Geology of Western Sind. Pt. 2, 1880 (*price* 2 Rs.): Trans-Indus extension of Punjab Salt-range.

- VOL. XVIII.** Pt. 1, 1881 (*price 2 Rs.*): Southern Afghanistan. Pt. 2, 1881 (*out of print*): Mánbhum and Singhbhum. Pt. 3, 1881 (*price 2 Rs.*): Pránbhitá, Godávari Valley.
- VOL. XIX.** Pt. 1, 1882 (*price 2 Rs.*): Cachar Earthquake of 1869. Pt. 2, 1882 (*price 1 Re.*): Thermal Springs of India. Pt. 3, 1883 (*price 1 Re.*): Catalogue of Indian Earthquakes. Pt. 4, 1883 (*out of print*): Geology of parts of Manipur and Nága Hills.
- VOL. XX.** Pt. 1, 1883 (*out of print*): Geology of Madura and Tinnevely. Pt. 2, 1883 (*out of print*): Geological notes on Hills in neighbourhood of Sind and Punjab Frontier between Quetta and Dera Ghazi Khan.
- VOL. XXI.** Pt. 1, 1884 (*out of print*): Geology of Lower Narbada Valley. Pt. 2, 1884 (*out of print*): Geology of Kathiawar. Pt. 3, 1885 (*out of print*): Coal-field of South Rewah. Pt. 4, 1885 (*out of print*): Barren Island.
- VOL. XXII.** 1883 (*price 5 Rs.*): Geology of Kashmir, Chamba, and Khagan.
- VOL. XXIII.** 1891 (*price 5 Rs.*): Geology of Central Himalayas.
- VOL. XXIV.** Pt. 1, 1887 (*out of print*): Southern Coal-fields of Sápura Gondwána basin. Pt. 2, 1890 (*out of print*): Geology of Sub-Himalaya of Garhwal and Kumaun. Pt. 3, 1890 (*out of print*): Geology of South Malabar, between Beypore and Ponnáni Rivers.
- VOL. XXV.** 1896 (*out of print*): Geology of Bellary District, Madras Presidency.
- VOL. XXVI.** 1896 (*out of print*): Geology of Hazara.
- VOL. XXVII.** Pt. 1, 1895 (*out of print*): Marine Fossils from Miocene of Upper Burma. Pt. 2, 1897 (*out of print*): Petroleum in Burma and its technical exploitation.
- VOL. XXVIII.** Pt. 1, 1898 (*price 2 Rs.*): Geological Structure of Chitichun region.—Allahbund in north-west of Rann of Kuchh.—Geology of parts of Myingyan, Magwè and Pakokku Districts, Burma.—Geology of Mikir Hills in Assam.—Geology of Tirah and Bazár Valley. Pt. 2, 1900 (*price 3 Rs.*): Charnockite Series, group of Archæan Hypertheneic Rocks in Peninsular India.
- VOL. XXIX.** 1900 (*price 5 Rs.*): Earthquake of 12th June 1897.
- VOL. XXX.** Pt. 1, 1900 (*price 2 Rs.*): Aftershocks of Great Earthquake of 12th June 1897. Pt. 2, 1900 (*price 1 Re.*): Geology of neighbourhood of Salem, Madras Presidency. Pt. 3, 1901 (*price 1 Re.*): Sivamalai Series of Elæolite-Syenites and Corundum Syenites. Pt. 4, 1901 (*price 1 Re.*): Geological Congress of Paris.
- VOL. XXXI.** Pt. 1, 1901 (*price 2 Rs.*): Geology of Son Valley in Rewah State and of Parts of Jabalpur and Mirzapur. Pt. 2, 1901 (*price 3 Rs.*): Baluchistan Desert and part of Eastern Persia. Pt. 3, 1901 (*price 1 Re.*): Peridotites, Serpentine, etc., from Ladakh.
- VOL. XXXII.** Pt. 1, 1901 (*price 1 Re.*): Recent Artesian Experiments in India. Pt. 2, 1901 (*price 2 Rs.*): Rampur Coal-field. Pt. 3, 1902 (*price 3 Rs.*): "Exotic Blocks" of Malla Johar in Bhot Mahals of Kumaon. Pt. 4, 1904 (*price 3 Rs.*): Jammu Coal-fields.
- VOL. XXXIII.** Pt. 1, 1901 (*price 8 Rs.*): Kolar Gold-field. Pt. 2, 1901 (*price 2 Rs.*): Art. 1: Gold-fields of Wainád. Art. 2: Auriferous Quartzites of Parhadiá, Chota Nagpur. Art. 3: Auriferous localities in North Coimbatore. Pt. 3, 1902 (*price 1 Re.*): Geology of Kalahandi State, Central Provinces.
- VOL. XXXIV.** Pt. 1, 1901 (*price 1 Re.*): Peculiar form of altered peridotite in Mysore State. Pt. 2, 1902 (*price 3 Rs.*): Mica deposits of India. Pt. 3, 1903 (*price 1 Re.*): Sandhills of Clifton near Karachi. Pt. 4, 1908 (*price 4 Rs.*): Geology of Persian Gulf and adjoining portions of Persia and Arabia.
- VOL. XXXV.** Pt. 1, 1902 (*price 2 Rs.*): Geology of Western Rajputana. Pt. 2, 1903 (*price 1 Re.*): Aftershocks of Great Earthquake of 12th June 1897. Pt. 3, 1904 (*price 1 Re.*): Seismic phenomena in British India and their connection with its Geology. Pt. 4 (*in the Press*): Geology of Andaman Islands, with references to Nicobars.
- VOL. XXXVI.** Pt. 1, 1904 (*price 4 Rs.*): Geology of Spiti. Pt. 2, 1907 (*price 3 Rs.*): Geology of Provinces of Tsang and Ü in Central Tibet. Pt. 3 (*in the Press*): Trias of the Himalayas.
- VOL. XXXVII.** 1909. Manganese-Ore Deposits of India: Pt. 1 (*price 3 Rs.*), Introduction and Mineralogy; Pt. 2 (*price 3 Rs.*), Geology; Pt. 3 (*price 3 Rs.*), Economics and Mining; Pt. 4 (*price 5 Rs.*), Description of Deposits.
- VOL. XXXVIII.** 1910 (*price 5 Rs.*): Kangra Earthquake of 4th April 1905.

PALÆONTOLOGIA INDICA.

(SER. I, III, V, VI, VIII).—CRETACEOUS FAUNA OF SOUTHERN INDIA, *by*
F. STOLICZKA, *except* VOL. I, Pt. 1, *by* H. F. BLANFORD.

SER. I & III.—VOL. I. The Cephalopoda (1861-65), pp. 216, pls. 84 (6 double).

V.—VOL. II. The Gastropoda (1867-68), pp. xiii, 500, pls. 28.

VI.—VOL. III. The Pelecypoda (1870-71), pp. xxii, 537, pls. 50.

VIII.—VOL. IV. The Brachiopoda, Ciliopoda, Echinodermata, Corals, etc. (1872-73), pp. v, 202, pls. 29.

(SER. II, XI, XII).—THE FOSSIL FLORA OF THE GONDWANA SYSTEM, *by*
O. FEISTMANTEL, *except* VOL. I, Pt. 1, *by* T. OLDHAM and J. MORRIS.

VOL. I, pp. xviii, 233, pls. 72. 1863-79. Pt. 1; Rájmahál Group, Rájmahál Hills, Pt. 2; *The same (continued)*. Pt. 3; Plants from Golapili. Pt. 4; Outliers on the Madras Coast.

VOL. II, pp. xli, 115, pls. 26. 1876-78. Pt. 1; Jurassic Flora of Kach. Pt. 2: Flora of the Jabalpur Group.

VOL. III, pp. xi, 64+149, pls. 80 (9 double) (I—XXXI+IA—XLVIIA). 1879-81. Pt. 1; The Flora of the Talchir-Karharbari beds. Pt. 2; The Flora of the Damuda and Panchet Divisions. Pt. 3; *The same (concluded)*.

VOL. IV, pp. xxvi, 25+66, pls. 35 (2 double) (I—XXI+IA—XIVA). Pt. 1 (1882); Fossil Flora of the South Rewah Gondwana basin. Pt. 2 (1886); Fossil Flora of some of the coal-fields in Western Bengal.

(SER. IX).—JURASSIC FAUNA OF KACH.

VOL. I (1873-76). The Cephalopoda, *by* W. WAAGEN, pp. i, 247, pls. 60 (6 double).

VOL. II, pt. 1 (1893). The Echinoidea of Kach, *by* J. W. GREGORY, pp. 12, pls. 2.

VOL. II, pt. 2 (1900). The Corals, *by* J. W. GREGORY, pp. 196, I—IX, pls. 26.

VOL. III, pt. 1 (1900). The Brachiopoda, *by* F. L. KITCHIN, pp. 87, pls. 15.

VOL. III, pt. 2 (1903). Lamellibranchiata: Genus Trigonina, *by* F. L. KITCHIN, pp. 122, pls. 10 (*out of print*).

(SER. IV).—INDIAN PRE-TERTIARY VERTEBRATA.

VOL. I, pp. vi, 137, pls. 26. 1865-85. Pt. 1 (1865); the Vertebrate Fossils from the Panchet rocks, *by* T. H. HUXLEY. Pt. 2 (1878); The Vertebrate Fossils of the Kota-Maleri Group, *by* SIR P. DE M. GREY EGERTON, L. O. MIALI, and W. T. BLANFORD. Pt. 3 (1879); Reptilia and Batrachia, *by* R. LYDEKKER. Pt. 4 (1885); The Labyrinthodont from the Bijori group, *by* R. LYDEKKER (*out of print*). Pt. 5 (1885); The Reptilia and Amphibia of the Maleri and Denwa groups, *by* R. LYDEKKER (*out of print*).

(SER. X).—INDIAN TERTIARY AND POST-TERTIARY VERTEBRATA, *by*
R. LYDEKKER, *except* VOL. I, Pt. 1, *by* R. B. FOOTE.

VOL. I, pp. xxx, 300, pls. 50. 1874-80. Pt. 1; Rhinoceros deccanensis. Pt. 2; Molar teeth and other remains of Mammalia. Pt. 3; Crania of Ruminants. Pt. 4; Supplement to Pt. 3. Pt. 5; Siwalik and Narbada Proboscidea.

VOL. II, pp. xv, 363, pls. 45. 1881-84. Pt. 1; Siwalik Rhinocerotidae. Pt. 2; Supplement to Siwalik and Narbada Proboscidea. Pt. 3; Siwalik and Narbada Equidae. Pt. 4; Siwalik Camelopardalidae. Pt. 5; Siwalik Selenodont Suina, etc. Pt. 6; Siwalik and Narbada Carnivora.

- Vol. III, pp. xxiv, 264, pls. 35. 1884-86. Pt. 1; Additional Siwalik Perissodactyla and Proboscidea. Pt. 2; Siwalik and Narbada Bunodont Suina. Pt. 3; Rodents and new Ruminants from the Siwaliks. Pt. 4; Siwalik Birds. Pt. 5; Mastodon Teeth from Perim Island. Pt. 6; Siwalik and Narbada Chelonia. Pt. 7; Siwalik Crocodilia, Lacertilia and Ophidia. Pt. 8; Tertiary Fishes.
- Vol. IV, pt. 1, 1886. Siwalik Mammalia (Supplement 1); pp. 18, pls. 6.
- Vol. IV, pt. 2, 1886. The Fauna of the Karnul caves (and addendum to pt. 1); pp. 40 (18-58), pls. 5 (vii-xi).
- Vol. IV, pt. 3, 1887. Eocene Chelonia from the Salt-range; pp. 7 (58-65), pls. 2 (xii-xiii).

(SER. VII, XIV.)—TERTIARY AND UPPER CRETACEOUS FAUNA OF WESTERN INDIA, by P. MARTIN DUNCAN and W. PERCY SLADEN, except Pt. 1, by F. STOLICZKA.

- Vol. I, pp. 16+110+382+91=599, pls. 5+28+58+13=104. 1871-85. Pt. 1: Tertiary Crabs from Sind and Kach. Pt. 1 (new 2): Sind Fossil Corals and Alcyonaria; by P. Martin Duncan. Pt. 3: The Fossil Echinoidea of Sind: *Fas. 1*, The *Cardita beaumonti* beds; *Fas. 2*, The Ranikot Series in Western Sind; *Fas. 3*, The Khirthar Series; *Fas. 4*, The Nari (Oligocene) Series; *Fas. 5*, the Gaj (Miocene) Series; *Fas. 6*, The Makran (Pliocene) Series; by Duncan and Sladen. Pt. 4: The Fossil Echinoidea of Kach and Kattywar, by Duncan, Sladen and Blanford.

(SER. XIII.)—SALT-RANGE FOSSILS, by WILLIAM WAAGEN, PH.D.

- Productus Limestone Group. Vol. I, pt. 1 (1879). Pisces, Cephalopoda, pp. 72, pls. 6.
- " " " " 2 (1880). Gastropoda and supplement to pt. 1, pp. 111 (73-183), pls. 10 (1 double), (vii-xvi).
- " " " " 3 (1881). Pelecypoda, pp. 144 (185-328), pls. 8 (xvii-xxiv).
- " " " " 4 (1882-85). Brachiopoda, pp. 442 (329-770), pls. 62 (xxv-lxxxvi).
- " " " " 5 (1885). Bryozoa-Annelida-Echinodermata, pp. 64 (771-834), pls. 10 (lxxxvii-xcvi).
- " " " " 6 (1886). Coelenterata, pp. 90 (835-924), pls. 20 (xcvii-cxvi).
- " " " " 7 (1887). Coelenterata, Protozoa, pp. 74 (925-998), pls. 12 (cxvii-cxxviii).
- Fossils from the Ceratite Formation: Vol. II, pt. 1 (1895). Pisces-Ammonoidea, pp. 324, pls. 40.
- Geological Results: Vol. IV, pt. 1 (1889), pp. 1-88, pls. 4 (out of print).
- " " " " 2 (1891), pp. 89-242, pls. 8 (out of print).

(SER. XV.)—HIMALAYAN FOSSILS.

- Upper-triassic and liassic faunas of the exotic blocks of Malla Johar in the Bhot Mahale of Kumaon: Vol. I, pt. 1 (1908), by Dr. C. Diener, pp. 100, pls. 16 (1 double).
- Anthracolithic Fossils of Kashmir and Spiti: Vol. I, pt. 2 (1899), by Dr. C. Diener, pp. 96, pls. 8.
- The Permocarboniferous Fauna of Chitichun No. I: Vol. I, pt. 3 (1897), by Dr. C. Diener, pp. 105, pls. 13.
- The Permian Fossils of the Productus Shales of Kumaon and Garhwal: Vol. I, pt. 4 (1897), by Dr. C. Diener, pp. 64, pls. 5.
- The Permian Fossils of the Central Himalayas: Vol. I, pt. 5 (1903), by Dr. C. Diener, pp. 204, pls. 10.
- The Cephalopoda of the Lower Trias: Vol. II, pt. 1 (1897), by Dr. C. Diener, pp. 182, pls. 23.
- The Cephalopoda of the Muschelkalk: Vol. II, pt. 2 (1895), by Dr. C. Diener, pp. 118, pls. 31.

- Upper Triassic Cephalopoda Fauna of the Himalaya : Vol. III, pt. 1² (1899), by Dr. E. von Mojsisovics, pp. 157, pls. 22.
 Trias Brachiopoda and Lamellibranchiata : Vol. III, pt. 2 (1899), by Alexander Bittner, pp. 76, pls. 12 (2 double).
 The Fauna of the Spiti Shales : Vol. IV, Pt. 1, Fasc. 1 (1903), pp. 132, pls. 18; Fasc. 2 (1910), pp. 133-306, pls. 47 (2 double). By Dr. V. Uhlig.
 The Fauna of the Tropites-Limestone of Byans : Vol. V, Memoir No. 1 (1906), by Dr. C. Diener, pp. 201, pls. 17 (1 double).
 The Fauna of the Himalayan Muschelkalk : Vol. V, Memoir No. 2 (1907), by Dr. C. Diener, pp. 140, pls. 17 (2 double).
 Ladinic, Carnic and Noric fauna of Spiti : Vol. V, Memoir No. 3 (1908), by Dr. C. Diener, pp. 167, pls. 24 (3 double).
 Lower-Triassic Cephalopoda from Spiti, Malla Johar and Byans : Vol. VI, Memoir No. 1 (1909), by Drs. A. von Krafft and C. Diener, pp. 186, pls. 31.
 The Fauna of the Traumatocrinus Limestone of Painkhanca : Vol. VI, Memoir No. 2 (1909), by Dr. C. Diener, pp. 39, pls. 5.
 The Cambrian Fossil of Spiti : Vol. VII, Memoir No. 1 (1910), pp. 70, pls. 6, by F. R. C. Reed.
 The Ordovician and Silurian fossils from the Central Himalaya : Vol. VII, Memoir No. 2 (*in the Press*), by F. R. C. Reed.

- (SER. XVI.)—BALUCHISTAN FOSSILS, by FRITZ NOETLING, Ph.D., F.G.S.
 The Fauna of the Kellaways of Mazâr Drik : Vol. I, pt. 1 (1895), pp. 22, pls. 13.
 The Fauna of the (Neocomian) Belemnite Beds : Vol. I, pt. 2 (1897), pp. 6, pls. 2.
 The Fauna of the Upper Cretaceous Maestrichtian Beds of the Mari Hills : Vol. I, pt. 3 (1897), pp. 79, pls. 23

(NEW SERIES.)

- The Cambrian Fauna of the Eastern Salt-range : Vol. I, Memoir 1 (1899), K. Redlich, pp. 14, pl. 1.
 Notes on the Morphology of the Pelecypoda : Vol. I, Memoir 2 (1899), Fritz Noetling, pp. 58, pls. 4.
 Fauna of the Miocene Beds of Burma : Vol. I, Memoir 3 (1901), Fritz Noetling, pp. 378, pls. 25 (*out of print*).
 Observations sur quelques Plantes Fossiles des Lower Gondwanas : Vol. II, Memoir 1 (1902), R. Zeiller, pp. 39, pls. 7.
 Permo-Carboniferous (Lower Gondwana) Plants and Vertebrates from Kashmir : (1) Plants, by A. C. Seward; (2) Fishes and Labyrinthodonts, by A. Smith Woodward : Vol. II, Memoir No. 2 (1905), pp. 13, pls. 3.
 The Lower Palaeozoic Fossils of the Northern Shan States, Upper Burma : Vol. II, Memoir No. 3 (1906), by F. R. C. Reed, pp. 154, pls. 8.
 The Fauna of the Napeng Beds or the Rhetic Beds of Upper Burma : Vol. II, Memoir No. 4 (1908), by Miss M. Healey, pp. 88, pls. 9.
 The Devonian Faunas of the Northern Shan States : Vol. II, Memoir No. 5 (1908), by F. R. C. Reed, pp. 183, pls. 20.
 The Mollusca of the Ranikot Series : Vol. III, Pt. 1, Memoir No. 1 (1909), pp. xix, 83, pls. 8, by M. Cossmann and G. Pissarro. Introduction, by E. W. Vredenburg.
 On some Fish-remains from the Beds at Dongargaon, Central Provinces : Vol. III, Memoir No. 3 (1908), by A. Smith Woodward, pp. 6, pl. 1.
 The Fossil Giraffidae of India : Vol. III, Memoir No. 4 (*in the Press*), by G. E. Pilgrim.

The price fixed for these publications is four annas (4 pence) per single plate, with a minimum charge of Re. 1.

RECORDS OF THE GEOLOGICAL SURVEY OF INDIA.

VOL. I, 1868.

- Part 1 (out of print).*—Annual report for 1867. Coal-seams of Tawa valley. Coal in Garrow Hills. Copper in Bundelkund. Meteorites.
- Part 2 (out of print).*—Coal-seams of neighbourhood of Chanda. Coal near Nagpur. Geological notes on Surat collection. Cephalopodous fauna of South Indian cretaceous deposits. Lead in Raipur district. Coal in Eastern Hemisphere. Meteorites.
- Part 3 (out of print).*—Gastropodous fauna of South Indian cretaceous deposits. Notes on route from Poona to Nagpur *via* Ahmednuggur, Jalna, Loonar, Yeotmalah, Mangal and Hingunghat. Agate-flake in pliocene (?) deposits of Upper Godavary. Boundary of Vindhyan series in Rajputana. Meteorites.

VOL II, 1869.

- Part 1 (out of print).*—Valley of Poorna river, West Berar. Kuddapah and Kurnool formations. Geological sketch of Shillong plateau. Gold in Singhboom, etc. Wells at Hazareebagh. Meteorites.
- Part 2.*—Annual report for 1868. Pangshura teata and other species of Chelonia from newer tertiary deposits of Nerbudda valley. Metamorphic rocks of Bengal.
- Part 3.*—Geology of Kuch, Western India. Geology and physical geography of Nicobar Islands.
- Part 4 (out of print).*—Beds containing silicified wood in Eastern Promé, British Burma. Mineralogical statistics of Kumaon division. Coal-field near Chanda. Lead in Raipur district. Meteorites.

VOL. III, 1870.

- Part 1.*—Annual report for 1869. Geology of neighbourhood of Madras. Alluvial deposits of Irrawadi, contrasted with those of Ganges.
- Part 2 (out of print).*—Geology of Gwalior and vicinity. Slates at Chitli, Kumaon. Lead vein near Chicholi, Raipur district. Wardha river coal-fields, Berar and Central Provinces. Coal at Karba in Bilaspur district.
- Part 3 (out of print).*—Mohpani coal field. Lead ore at Sumanabad, Jabalpur district. Coal east of Chhattisgarh between Bilaspur and Ranchi. Petroleum in Burma. Petroleum locality of Sudkal, near Futtiyung, west of Rawalpindi. Argentiferous galena and copper in Manbhūm. Assays of iron ores.
- Part 4 (out of print).*—Geology of Mount Tilla, Punjab. Copper deposits of Dalbhum and Singbhum : 1.—Copper mines of Singbhum : 2.—Copper of Dalbhum and Singbhum. Meteorites.

VOL. IV, 1871.

- Part 1.*—Annual report for 1870. Alleged discovery of coal near Gooty, and of indications of coal in Cuddapah district. Mineral statistics of Kumaon division.
- Part 2.*—Axial group in Western Promé. Geological structure of Southern Konkan. Supposed occurrence of native antimony in the Straits Settlements. Deposit in boilers of steam-engines at Raniganj. Plant-bearing sandstones of Godavari valley, on southern extensions of Kamthi group to neighbourhood of Ellore and Rajamandri, and on possible occurrence of coal in same direction.
- Part 3.*—Borings for coal in Godavari valley near Dumagudem and Bhadrachalam. Nerbudda coal-basin. Geology of Central Provinces. Plant-bearing sandstones of Godavari valley.
- Part 4.*—Ammonite fauna of Kutch. Raigur and Hengir (Gangpur) Coal-field. Sandstones in neighbourhood of first barrier on Godavari, and in country between Godavari and Ellore.

VOL. V, 1872.

- Part 1.*—Annual report for 1871. Relations of rocks near Murree (Mari), Punjab. Mineralogical notes on gneiss of South Mirzapur and adjoining country. Sandstones in neighbourhood of first barrier on Godavari, and in country between Godavari and Ellore.
- Part 2.*—Coasts of Baluchistan and Persia from Karachi to head of Persian Gulf, and some of Gulf Islands. Parts of Kummummet and Hanamconda districts in Nizam's Dominions. Geology of Orissa. New coal-field in south-eastern Hyderabad (Deccan) territory.

- Part 3.*—Maskat and Massandim on east coast of Arabia. Example of local jointing. Axial group of Western Promae. Geology of Bombay Presidency.
- Part 4.*—Coal in northern region of Satpura basin. Evidence afforded by raised oyster banks on coasts of India, in estimating amount of elevation indicated thereby. Possible field of coal-measures in Godavari district, Madras Presidency. Lameta or intratrappean formation of Central India. Petroleum localities in Pegu. Supposed eoconal limestone of Yellam Bile.

VOL. VI, 1873.

- Part 1.*—Annual report for 1872. Geology of North-West Provinces.
- Part 2.*—Bisrampur coal-field. Mineralogical notes on gneiss of south Mirzapur and adjoining country.
- Part 3.*—Celt in ossiferous deposits of Narbada valley (Pliocene of Falconer): on age of deposits, and on associated shells. Barakars (coal-measures) in Beddadanois field, Godavari district. Geology of parts of Upper Punjab. Coal in India. Salt-springs of Pegu.
- Part 4.*—Iron deposits of Chanda (Central Provinces). Baren Islands and Naikondam. Metalliferous resources of British Burma.

VOL. VII, 1874.

- Part 1 (out of print).*—Annual report for 1873. Hill ranges between Indus valley in Ladak and Shah-i-Dula on frontier of Yarkand territory. Iron ores of Kumaon. Raw materials for iron smelting in Raniganj field. Elastic sandstone, or so called Itacolymite. Geological notes on part of Northern Hazaribagh.
- Part 2 (out of print).*—Geological notes on route traversed by Yarkand Embassy from Shah-i-Dula to Yarkand and Kashgar. Jade in Karakas valley, Turkistan. Notes from Eastern Himalaya. Petroleum in Assam. Coal in Garo Hills. Copper in Narbada valley. Potash-salt from East India. Geology of neighbourhood of Mari hill station in Punjab.
- Part 3.*—Geological observations made on a visit to Chaderkul, Thian Shan range. Former extension of glaciers within Kangra district. Building and ornamental stones of India. Materials for iron manufacture in Raniganj coal-field. Manganese-ore in Wardha coal-field.
- Part 4 (out of print).*—Auriferous rocks of Dhambal hills, Dharwar district. Antiquity of human race in India. Coal recently discovered in the country of Luni Pathans, south-east corner of Afghanistan. Progress of geological investigation in Godavari district, Madras Presidency. Subsidiary materials for artificial fuel.

VOL. VIII, 1875.

- Part 1.*—Annual report for 1874. The Altum-Artush considered from geological point of view. Evidences of 'ground-ice' in tropical India, during Talcir period. Trials of Raniganj fire-bricks.
- Part 2 (out of print).*—Gold-fields of south-east Wynaad, Madras Presidency. Geological notes on Khareean hills in Upper Punjab. Water-bearing strata of Surat district. Geology of Scindia's territories.
- Part 3 (out of print).*—Shahpur coal-field, with notice of coal explorations in Narbada region. Coal recently found near Motlong, Khasia Hills.
- Part 4 (out of print).*—Geology of Nepal. Raigarh and Hingir coal-fields.

VOL. IX, 1876.

- Part 1 (out of print).*—Annual report for 1875. Geology of Sind.
- Part 2.*—Retirement of Dr. Oldham. Age of some fossil floras in India. Cranium of Stegodon Ganesa, with notes on sub-genus and allied forms. Sub-Himalayan series in Jamu (Jammoo) Hills.
- Part 3.*—Fossil floras in India. Geological age of certain groups comprised in Gondwana series of India, and on evidence they afford of distinct zoological and botanical terrestrial regions in ancient epochs. Relations of fossiliferous strata at Maleri and Kota, near Sironcha, C. P. Fossil mammalian faunas of India and Burma.
- Part 4.*—Fossil floras in India. Osteology of *Merycopotamus dissimilis*. Addenda and Corrigenda to paper on tertiary mammalia. Plesiosaurus in India. Geology of Pir Panjal and neighbouring districts.

VOL. X, 1877.

- Part 1.*—Annual report for 1876. Geological notes on Great Indian Desert between Sind and Rajputana. Cretaceous genus *Omphalia* near Nameho lake, Tibet, about 75 miles north of Lhasa. *Etheria* in Gondwana formation. Vertebrata from Indian tertiary and secondary rocks. New Emydine from the upper tertiaries of Northern Punjab. Observations on under-ground temperature.

Part 2.] 1910. [September

CONTENTS.

B

ECONOMIC ENQUIRIES—

	PARAS.	PAGE.
Coal : Raniganj, Rajmahal Hills, Punjab Salt Range, Sikkim	34—37	94
Copper : Sikkim, Gwalior	38, 39	95
Engineering Questions : Building sites at Dalhousie, Cauvery River Project	40, 41	96
Fireclay : Gwalior	42	97
Galena : Gwalior	43	97
Petroleum : Burma ; Oil-fields Committee, Itamri Island, Minbu District, Palokku District, Myingyan District ; Las Bela	44—49	97
Road metal and Building stone : Road metal for Rangoon, Taungu stone quarries	50—51	100
Salt : Myingyan	52	101
Water : Baluchistan, Bengal, Bombay, Burma, Central India, Eastern Bengal and Assam, Punjab, United Provinces	53—66	102

GEOLOGICAL SURVEYS—

Aden Hinterland	67	106
Burma : Thaton District, Yenangyaung, Popa Volcano, country south of Popa, Western Prome	68—76	107
Central India and Rajputana : Indore and Jaora, Gwalior, Alwar, Partabgarh and Banswara	77—95	111
Punjab : Tertiary freshwater strata	96—99	119
Kashmir	100—102	121

INTRODUCTION.

THIS report contains a summary of the operations conducted by the Geological Survey of India during the calendar year 1909. In certain cases the results of these operations have already appeared in the publications of the Department, and these are only briefly referred to here. The work still in progress in Rajputana and in Burma is, however, not yet completed, and is accordingly described in somewhat greater detail.

2. The issue of the Quinquennial Review of Mineral Production for the period 1904—1908 has been considerably delayed because Sir T. Holland, who was engaged in compiling it, proceeded on leave in September, and was compelled to hand over the duty of completing it to Dr. L. L. Fermor. Moreover, the progress made by the mineral industry in this country during the period in question has so greatly exceeded that of the preceding six years, an account of which appeared in *Records* G.S.I., Vol. XXXII, Pt. 1, that not only has it taken a longer time to collect and arrange the material, but it has also been found necessary to set apart a whole volume of the *Records* (Vol. XXXIX) for its accommodation. The returns of Mineral Production for the year 1909 are dealt with briefly in the present issue of the *Records* and may be considered as a supplement to the Review. A list of licenses and leases granted for prospecting and mining in Government lands is appended.

DISPOSITION LIST.

3. During the period under report the officers of the Department were employed as follows :—

Superintendents.

- MR. T. H. D. LA TOUCHE** . Returned to headquarters from the Salt Range, Punjab, on the 18th February 1909. Proceeded to Sikkim on the 24th March 1909 to examine copper-ore deposits and to survey certain glaciers. Returned to headquarters on the 8th July 1909. Assumed duties as Officiating Director from the 1st September 1909.
- MR. C. S. MIDDLEMISS** . Proceeded to the field on the 1st March 1909 in charge of the Rajputana and Central India party and returned to headquarters on the 11th April 1909. Deputed on the 27th April 1909 to Kashmir to survey the plant-bearing beds underlying the Zewan stage of Kashmir. Returned to headquarters on the 30th October 1909. Placed in charge of the Central India party for extension of the geological map over previously unsurveyed areas in Central India and the neighbouring States of Rajputana.
- MR. H. H. HAYDEN** . At headquarters in charge of office up to the 10th November 1909. Deputed to survey the coalfields of North-East Assam and left for the field on the 16th November 1909.

Assistant Superintendents.

- MR. P. N. DATTA** . Returned from Lower Burma on the 8th April 1909. Granted privilege

leave for six weeks with effect from the 28th September 1909. Returned from leave on the 8th November 1909. Deputed to the Central Provinces for continuation of geological survey of the Chanda and Raipur districts and left for the field on the 29th November 1909.

MR. E. VREDENBURG

At headquarters as Palæontologist.

DR. L. L. FERMOR

At headquarters seeing the memoir of the Manganese-ore Deposits of India through the press and working on the results obtained from the survey of the Singhbhum district. Granted one month's privilege leave with effect from the 12th October 1909. Returned from leave on the 8th November 1909 and placed in charge of the office on the 10th November 1909. Deputed from the 1st to 16th December to the Lahore Industrial and Agricultural Exhibition.

DR. G. E. PILGRIM

Returned from the field on the 28th April 1909. Granted privilege leave for one month and 3 days with effect from the 15th September 1909. Returned from leave on the 1st November 1909. Appointed Curator on the 26th November 1909.

MR. G. H. TIPPER

At headquarters as Curator up to the 25th November 1909. Deputed on the 26th November to report on the monazite occurrences of Travancore State.

MR. H. WALKER

Returned to headquarters on the 30th April 1909. Deputed on the 6th

July 1909 to report on the site for a proposed dam on the Cauvery river, Madras. Returned to headquarters on the 24th July 1909. Granted privilege leave for 23 days with effect from the 24th September 1909. Returned from leave on the 1st November 1909. Deputed to revise the geological map of the Raniganj coalfield in conjunction with a Committee appointed by the Mining and Geological Institute of India and left for the field on the 18th November 1909.

MR. E. H. PASCOE

Returned from Burma on the 22nd August 1909. At headquarters preparing memoir on the Burma oil-fields.

MR. K. A. K. HALLOWES

Returned to headquarters on the 25th May 1909. Posted to the Burma party and left for the field on the 14th November 1909.

MR. G. DEP. COTTER

Returned to headquarters on the 20th May 1909. Left on the 1st August 1909 to relieve Mr. Pascoe in Burma. Placed in charge of the party for the survey of the Tertiary oil bearing regions in Upper Burma.

MR. J. COGGIN BROWN

Deputed again to Yunman for Natural History explorations.

MR. J. J. A. PAGE

Returned from the field on the 11th July 1909. Deputed on the 17th November 1909 to survey the Dalbhum Estate, Singhbhum, with special attention to occurrences of minerals of economic value. Granted 3 months' privilege leave with effect from the 9th December 1909.

MR. H. C. JONES

Returned to headquarters on the 17th May 1909. Granted privilege leave for 23 days with effect from the 28th September 1909. Returned from leave on the 1st November 1909. Re-posted to Central India for continuation of the survey of Gwalior State and left for the field on the 17th November 1909.

MR. A. M. HERON

Returned from the field on the 19th May 1909. Granted privilege leave for 23 days with effect from the 24th September 1909. Returned from leave on the 1st November 1909. Re-posted to the Central India and Rajputana party to survey the Alwar State, Rajputana, and Korana Hills, Punjab, and to report on the earthquake of the 21st October 1909 in the Sibi district, Baluchistan. Left for the field on the 20th November 1909.

MR. M. STUART

Returned from Burma on the 18th May 1909. Re-posted to the Burma party for the survey of the Prome and Thayetmyo districts, Burma, and left for the field on the 14th November 1909.

MR. N. D. DARU

Returned to headquarters on the 21st May 1909. Granted privilege leave for 3 weeks with effect from the 1st November 1909. Returned from leave on the 22nd November 1909 and re-posted to the Central India and Rajputana party to survey the Banswara State, Rajputana.

Chemist.

- DR. W. A. K. CHRISTIE** . Deputed on the 3rd December 1909 to the Lahore Industrial Exhibition and to the Mayo Salt Mines, Khewra, to collect samples of salt. At headquarters for the rest of the period under report.

Sub-Assistants.

- S. SETHU RAMA RAU** . Returned to headquarters on the 20th May 1909. Posted to the Burma party and left for the field on the 14th November 1909.
- M. VINAYAK RAO** . Returned from the field on the 6th June 1909. Deputed to collect mammalian remains in the Siwalik rocks of the Punjab under the instruction of Dr. Pilgrim and left for the field on the 14th November 1909.

Assistant Curator.

- MR. T. R. BLYTH** . On duty at headquarters throughout the period under report.

STUDENTS IN TRAINING.

4. The following students were under training during the year :—

G. G. NARKE, M.A., holding a scholarship from the Central Provinces Administration, continued to work with Mr. Walker of the Raniganj coalfield till his scholarship terminated on the 31st March 1909. He was then appointed as a temporary Museum Assistant in the Geological Survey. On the 11th August 1909 he resigned this appointment and proceeded to England as a State Technical Scholar.

KIRAN KUMAR SEN-GUPTA, M.A., B.Sc., a Research Scholar appointed by the Bengal Government, was deputed to study the wolfram deposits in the neighbourhood of Agarpara in the Nagpur District under the supervision of Dr. Fermor.

S. R. GHATPANDE, appointed by the Indore Durbar, continued to work with Mr. Jones in Central India, and on return from the field was trained at headquarters.

BYAS SANKAR LALL, B.A., appointed by the Marwar Durbar, continued to work with Mr. Heron on the Aravalli Series in the Alwar State and at headquarters on return from the field.

SHEO PRASAD GARGAVA, B.A., B.Sc., appointed by the Gwalior Durbar in November 1908, after being trained at headquarters, joined Mr. Jones in the Gwalior State.

LALA JOTI PERSHAD, B.A., appointed by the Kashmir Durbar in December 1908, after training at headquarters accompanied Mr. Middlemiss to Kashmir.

SYED ABDUL KARIM, B.A., was appointed by the Hyderabad Durbar in July 1909, and has been kept at headquarters for training.

5. One of the previous year's students who was found not to be sufficiently qualified for training returned to his State in March 1909. The remaining students have been favourably reported on, and one of them, Kiran Kumar Sen-Gupta, has recently been appointed State Geologist in Cochin.

ADMINISTRATIVE CHANGES.

6. Mr. T. H. D. LA TOUCHE, Superintendent, was appointed to officiate as Director with effect from the 1st September 1909, *vice* Sir T. H. Holland on combined leave.

Appointments.

Dr. G. E. PILGRIM was appointed Curator with effect from the 26th November 1909.

7. Mr. E. VREDENBURG, Assistant Superintendent, was appointed to officiate as Superintendent with effect from the 1st September 1909, *vice* Mr. T. H. D.

Promotion.

La Touche appointed to officiate as Director.

8. The following officers were confirmed in their appointments as officers of the Geological Survey Department :—

Confirmation.

Mr. M. STUART,
Mr. N. D. DARU.

9. Sir T. H. HOLLAND was granted privilege leave for three months combined with furlough for one year with effect from the 1st September 1909.

Leave.

Mr. P. N. DATTA was granted privilege leave for six weeks with effect from the 28th September 1909.

Dr. L. L. FERMOR was granted privilege leave for one month with effect from the 12th October 1909.

Dr. G. E. PILGRIM was granted privilege leave for one month and three days with effect from the 15th September 1909.

Mr. H. WALKER was granted privilege leave for 23 days with effect from the 24th September 1909.

Mr. J. J. A. PAGE was granted privilege leave for three months with effect from the 9th December 1909.

Mr. H. C. JONES was granted privilege leave for 23 days with effect from the 28th September 1909.

Mr. A. M. HERON was granted privilege leave for 23 days with effect from the 24th September 1909.

Mr. N. D. DARU was granted privilege leave for three weeks with effect from the 1st November 1909.

LIBRARY.

10. The additions to the Library during the period 1st January to 31st December 1909 amounted to 3,275 volumes, of which 1,188 were acquired by purchase and 2,087 by presentation.

MUSEUM AND LABORATORY.

11. Mr. G. H. Tipper was Curator of the Museum and Laboratory until the end of November, when he left for Travancore to investigate the monazite sands of that state, Dr. G. E. Pilgrim taking over the duties of Curator. Mr. T. R. Blyth was Assistant Curator throughout the year and he continued to work with his customary earnestness and ability. Babu Bankim Behari Gupta, Museum Assistant for Palæontology, has continued to work creditably.

12. Dr. W. A. K. Christie, Chemist, was engaged principally in an investigation of the origin of the Rajputana salt deposits. The main conclusions arrived at have been published in a joint paper by Sir Thomas Holland and himself in the *Records* (Vol.

XXXVIII, Part 2). The enquiry into the probable duration of the resources of the Sambhar Salt Lake was continued. Besides the routine work of the laboratory a critical enquiry was made into the published methods for the determination of thorium in monazite sands in connection with the deposits in Southern India. None of the published methods tested gave reliable results; and a satisfactory separation has not yet been found. In December Dr. Christie was deputed to Lahore in connection with the Punjab Industrial Exhibition and at the end of the year was engaged in prospecting for deposits of potassium salts in the Punjab Salt Range.

13. The following students, Messrs. G. G. Narke, K. K. Sen-Gupta, S. R. Ghatpande, Byas Shankar Lal, Sheoprasad Gargava, Joti Pershad, and Syed Abdul Karim received training in the laboratory, chiefly during the recess. The work done was mainly determinative mineralogy with an occasional piece of simple analytical research work.

14. During the year there was a marked decrease in the number of specimens referred to the Curator for
Determinative **and** determination. The number examined was
Chemical work. 361, compared with 767, in 1908. Of these assays and analyses were made of 39, a decrease of 28 on the previous year. This decrease can be explained as due to the increased number of trained prospectors at work in India, in consequence of which only the more complicated minerals and rocks are sent in for determination. Among the special pieces of work in the Laboratory may be mentioned the identification by Mr. Blyth of some specimens of samarskite, a rare niobate and tantalate containing uranium. This mineral is now known to occur in considerable quantity at the Sankara mica mine, Rapur taluq, Nellore district, Madras Presidency. Mr. Blyth also discovered among the Sikkim Copper minerals tetradymite and a cobalt mineral allied to cobaltite. Mr. Tipper investigated the triplite and accessory minerals from the Singar mica mines, Gaya district. Among the accessory minerals, columbite, zircon and pitchblende occur. The latter mineral which is of great importance as a source of radium, occurs as small rounded patches with aureoles of uranium ochre but never in any quantity.

15. No meteoric fall was recorded in India during the year and
Meteorites. there were no acquisitions by exchange.

16. Dr. L. L. Fermor arranged show cases to exhibit the manganese ores of India and the rocks in which they occur.

Museum.

The Museum Assistant for Palæontology arranged a series of Eocene fossils from the Paris basin and revised the collection of Lower Gondwana and Rajmahal plants.

The re-arrangement of the mineral collection and re-labelling of the rocks were continued.

Among the more interesting acquisitions to the collections may be mentioned :—

- (1) A large series (58) of Russian minerals, chiefly from the Urals, through the Imperial Academy of Science, St. Petersburg, in exchange for a collection of Indian rocks.
- (2) The following new minerals presented by the British Museum :—
 Rinneite from Prussia.
 Smithite and Hutchinsonite from Switzerland.
 Harttite and Goreixite from Brazil.
 Patronite from Peru.
 Tarbuttite from Rhodesia.
- (3) A fine specimen of Hambergite by purchase.

EXHIBITION.

17. Dr. L. L. Fermor prepared a series of mineralogical specimens for the Industrial Exhibition held at Lahore during the cold season 1909-1910 and was engaged for a fortnight in December in arranging it. The Chemist, Dr. Christie, also visited the Exhibition in connection with the enquiry that he is now making as regards the commercial value of the potassium salts found in the Punjab Salt Range.

PETROLOGY.

18. A large number of petrographical determinations have been made by Mr. Jones of the rocks collected by him in the Gwalior State, and by Mr. Heron of the Alwar rocks, but no types of particular interest have been found among them. A general account of these rocks is given in the section on Geological Surveys below (pp. 112,114).

Rocks from Gwalior and Alwar.

19. Mr. Vredenburg has worked out the petrology of the rocks collected by Captain R. E. Lloyd, in the hill country north of Aden (see below p. 106).
Rocks of the Aden Hinterland. The assemblage of specimens from the older volcanic series, resembling that of the Upper Cretaceous formation in Baluchistan and Persia, together with their superposition upon the Jurassic rocks, leaves little doubt that they belong to the same period of volcanic activity as the Deccan Trap. The acid varieties are represented by rhyolitic lavas, rhyolite breccias and ash beds, and there are also some doubtful andesites. Among the basic rocks there are dolerites with beautiful pleochroic augites of purple colour; a dolerite closely resembling many of the dyke rocks of Deccan trap age occurring in Baluchistan; ordinary basalts without olivine, also resembling the Deccan trap; basalts with olivine, and an abnormal rock made up of a base composed of small prismatic crystals of augite, iron ores, and serpentinous material, through which are scattered vacuoles filled with felspar and epidote; and olivine porphyry. Geodes of agate, chalcedony, jasper, etc., are extremely common in the basalts, and may be picked up in large quantities on the surface as in the Deccan trap areas in India. Mr. Vredenburg's notes are published in Vol. XXXVIII, Pt. 4, of the *Records*.

PALÆONTOLOGY.

20. Mr. E. Vredenburg carried on the duties of Palæontologist throughout the year and continued his researches upon the Tertiary and Cretaceous collections.
Palæontologist.

21. The collections of fossils made by Captain R. E. Lloyd in the hill country north of Aden have been examined by Mr. Tipper, whose notes on them are published in Vol. XXXVIII, Pt. 4, of the *Records*. They consist of a Belemnite, *B. cf. truganensis* Futterer; four species of *Perisphinctes*; an undetermined gasteropod closely resembling *Dicrolema* (*Pietitia*) *seminudum* Heb. & Desl.; among lamellibranchs *Parallelodon egertonianum* Etol., and species of *Pinna*, *Trigonia*, *Pecten* (*Synchelonema*) and *Cardinia*?; and a species of *Pentacrinus*. Mr. Tipper considers that the fauna described possesses a distinctly Upper Jurassic facies.

22. In a paper contributed to the *Records* (Vol. XXXVIII, pt. 3), Mr. Hayden has given a description of various *Fusulinidæ* collected by him in the limestones of the Bamian valley in Afghanistan. The material described consists chiefly of well-known forms and includes *Fusulina uralica* Krotow, *F. elongata* Shumard, *Schwagerina princeps* Ehr., *Neoschwagerina craticulifera* Schw. and *N. (Sumatrina) annæ* Volz. A new species, *Neoschwagerina primigena*, is described, intermediate between *Schwagerina (Doliolina) lepida* Schw. and *N. craticulifera* and the last named fossil is shown to be dimorphic.

Mr. Hayden also made a critical examination of the nature of the shell of the *Fusulinidæ*, which he found to be composed of crypto-crystalline material identical in structure with the shell-substance of the *Percellanea* and he pointed out that certain authors had mistaken the dark shell-wall for perforations and *vice versâ*. At the time of writing his paper, he had not seen the very important memoir by Professor Douvillé, which had previously appeared in the *Bulletin de la Société géologique de France*; he was not aware, therefore, that the latter author had come to the conclusion that the so-called perforations of *Fusulina* were in reality gaps in a net-work of varying degrees of fineness, and that this net-work was covered by a thin imperforate layer, to which attention had already been drawn by Girty. In Mr. Hayden's specimens the gaps in the net-work ('perforations') are frequently seen to traverse this outer layer, which therefore appears to be 'perforate'. It is of course possible that this may be due to the state of preservation of the specimens and, with a view to deciding this, Mr. Hayden is at present in correspondence with M. Douvillé on the subject.

23. Mr. Murray Stuart has described and figured a number of fossil fish teeth, collected from various localities in Burma, in Vol. XXXVIII, Pt. 4, of the *Records*. The evidence afforded by these is in favour of the classification of the Tertiary strata in Burma put forward by him in the paper noticed below (p. 110).

24. Messrs. Vredenburg and Stuart describe in Vol. XXXVIII, Pt. 2, of the *Records* the occurrence of *Ostrea latimarginata*, a species characteristic of the Gaj groups of Kachh and Sind, in the Yen-

gyaung Stage of the Pegu System in Upper Burma. The fossil was discovered by Mr. H. J. Davies, Geologist to the Burma Oil Co., and throws much light upon the vexed question of the correlation of the Tertiary rocks in Burma. Mr. Stuart considers that the Kama clay, which occurs immediately above the zone of *O. latimarginata*, must represent a part of the 'Hinglaj beds' of Mekran, as defined by Mr. Vredenburg, and confirms the suggestion that a distinct unconformity separates this Kama clay from the base of the Irrawaddy System. This observation is of importance, as it accounts for the extreme divergence in the thickness of the Kama clay which, as recent surveys have shown, constitutes the main petroliferous horizon in Burma; whereas Dr. Noetling considered that at Yenangyaung the oil sands occurred at a lower horizon, *i.e.*, in the Lower Prome beds of Mr. Theobald (*see below* p. 110.)

25. Mr. Vredenburg has described, in *Records*, Vol. XXXVIII, Pt. 3, two interesting species of *Hippurites* from a collection made in Seistan by Mr. T. R. J. Ward and Sir Henry McMahon, and gives in the same paper a geological sketch of the country. The two species of *Hippurites* described are *H. gosaviensis* Douvillé and a new species *Pirona persica* Vred., and Mr. Vredenburg considers the beds to be most probably uppermost Turonian. A large ribbed bivalve, which Mr. Vredenburg was unable to identify at the time his paper was written, has since been shown by Dr. Emil Böse of Mexico to be a species of *Chondrodonta*, a genus distinguished by the peculiar interlocking chondrophores of the hinge, and associated with shells of the Rudistæ in Europe and America. Mr. Vredenburg has consequently given the name of *Chondrodonta Bösei* to the Seistan species.

26. As a result of the exploration of the Tertiary ossiferous deposits of India now being carried out by Dr. G. E. Pilgrim, with the assistance of Sub-Assistant M. Vinayak Rao, it has been found necessary to establish several new genera and species of mammals. A preliminary list of these is published in the present volume of the *Records*, Pt. 1, and full descriptions of those forms which have been determined up to the present are now in the press.

7. The examination of the Triassic fossils from the Himalaya collected at various times by the late Mr. C. L. Griesbach, the late Dr. A. von Krafft, Dr. Diener, Mr. Hayden and others has now been completed, and Dr. Diener has summed up the whole question of the distribution and correlation of the Triassic rocks in the four distinct areas from which the fossils have been obtained, viz., Painkhanda, Spiti, Eastern Johar and Byans, and the exotic blocks between Malla Johár and Hundes, in an exhaustive paper which will shortly appear as Vol. XXXVI, Pt. 3, of the *Memoirs*.

The more recent researches of Hayden and von Krafft have shown that the Trias is not developed uniformly throughout the Himalaya, and that there is no 'type section' to which the development of the system in various localities can be referred. Thus the present memoir supersedes the summary of the Trias of Asia, so far as the Himalaya is concerned, published by Dr. Noetling in the *Lethæa Mesozoica* (Vol. I, Pt. 2, Stuttgart, 1905). The Triassic beds of the Himalaya were divided by him into ten cephalopod-bearing horizons thus : --

UPPER TRIAS.	{	10. <i>Sagenites</i> beds.
		9. <i>Halorites</i> beds.
		8. <i>Hauerites</i> beds.
		7. <i>Tropites</i> beds.
		6. <i>Journites</i> beds.
MIDDLE TRIAS.	{	5. <i>Ptychites</i> beds.
		4. <i>Robustites</i> beds.
LOWER TRIAS	{	3. <i>Stephanites</i> beds.
		2. <i>Hedenstræmia</i> beds.
		1. <i>Prionolobus</i> beds.

The base of the Trias was drawn above the *Otoceras* horizon, which Griesbach considered to be a passage bed between the Permian and Trias. It is now shown, however, that *Otoceras* is confined to a thin layer at the base of the Lower Trias.

The sub-division of the whole system now adopted by Dr. Diener is shown in the following table, which also indicates the variations

SPLIT.	THICKNESS.	PAINEHANDA.	THICKNESS.	BYANS.	THICKNESS.	EQUIVALENTS IN THE EASTERN ALPS.
Megalodon limestone ¹		Megalodon limestone		Megalodon limestone		Upper.
Quartzite series (<i>Spirifer Manitensis</i>)	Feet. 30	Quartzite series (<i>Spirifer Manitensis</i>)	Feet 20			Middle
Monotis beds (<i>Monotis salinarum</i>)	300	Anodontophora (Gris) beds (<i>Spirifer</i> beds)	160			XONIC STAGE
Coral limestone (<i>Spirifer and Cristobal</i>)	100	Limestone with <i>Spirifer</i> and <i>Gris</i> beds	320	Greenish black shales with sandy limestones	1,000	
Juvvites beds	500	Halorag beds. Nodular limestone with <i>Productus</i> and <i>Cristobal</i>	200			
Dolomitic limestone (<i>Limestone</i>)	600			Trapt limestone		Lower
Tropites shales (<i>Tropites subbulbus</i>)	600					Juvvite
		beds with <i>Halorag</i> and <i>comul</i>	800			CAPRIC STAGE.
Grey beds. Higher beds with brachiopods and limestones near base <i>Tropites</i> and <i>Cypripedium</i>	500			Grey massive limestone		Juvvite
Milobite limestone (<i>Halobolus</i>)	150	Trapt limestone	20			Cordovite
Dolomitic limestone. Higher beds with <i>Dolomite</i> near base <i>Dolomite</i>	150	Productus beds of the shales	10			FADNIC STAGE
Dolomite shales (<i>Dolomite</i>)	100		20			
Upper Muchoilk (<i>Productus</i>)		Upper Muchoilk (<i>Productus</i>)		Trapt limestone		MIDDLE TRIAS
Bed with <i>Spirifer</i> and <i>Productus</i>		Bed with <i>Spirifer</i> and <i>Productus</i>		Limestone with <i>Productus</i> and <i>Trapt</i>		
Niti limestone. Shale bed with <i>Productus</i> and <i>Trapt</i>	100	Niti limestone. Shale bed with <i>Productus</i> and <i>Trapt</i>	100			LOWER TRIAS
Heinrichs beds (<i>Heinrichs</i>)		Heinrichs beds (<i>Heinrichs</i>)				CAMILL BEDS
Melchior beds (<i>Melchior</i>)	10	Melchior beds (<i>Melchior</i>)				SLY BEDS
Ophites 11 (<i>Ophites</i>)	..	Ophites 11 (<i>Ophites</i>)				
Ophites bed (<i>Ophites</i>)	..	Ophites bed (<i>Ophites</i>)				
Kuling shales		Kuling or Productus Shales		Kuling or Productus shales		PLUVIAN.

¹ In the classification now employed by the Geological Survey of India, this term has been discarded for Stoliczka's original name "Paine stage" (see Bulletin of Hayden, Geology and Geography of the Himalaya, p. 230).

² "Nodular limestone" of the Geological Survey of India classification.

that occur in the three principal areas from which collections have been made.

Fifteen cephalopod-bearing horizons are distinguished by Dr. Diener, as shown in the following table. Of these three are rather doubtful, No. 5 being perhaps not an independent palæontological horizon, though *Rhynchonella Griesbachi* is confined to it; while from No. 9 only a single ammonite is known, *Joannites thanamensis*, and No. 15 is based on two fragmentary specimens of ammonites :—

	SPITI.	PAINKHANDA.	BYANS.	EXOTIC BLOCKS OF CHITICHUN AND MALLA JOHAR.
NORIC STAGE.	15. Horizon of <i>Trachypyraspi-</i> <i>dites</i> aff. <i>Griffithi</i> . 11. Horizon of <i>J.</i> <i>voelfes angulatus</i> .	15. Horizon of <i>Sag-</i> <i>enites</i> sp. ind. 14. Horizon of <i>Halo-</i> <i>rites procyon</i> . 13. Horizon of <i>Pro-</i> <i>cydonautilus Gries-</i> <i>bachi</i> .		
CARNIC STAGE.	12. Horizon of <i>Tropites subbul-</i> <i>latus</i> . 10. Horizon of <i>Joan-</i> <i>nites cymborformis</i> . 9. Horizon of <i>Joan-</i> <i>nites thanamen-</i> <i>sis</i> .	12. Horizon of <i>Mojs-</i> <i>varites eugyrus</i> . 11. Horizon of <i>Jura-</i> <i>vites tonkinensis</i> and <i>Hypoclad-</i> <i>iscites subaratus</i> . 10. Horizon of <i>Joan-</i> <i>nites cymborformis</i> .	14. } Horizon of 13. } <i>Tropites subbul-</i> 12. } <i>latus</i> and <i>Halo-</i> <i>rites</i> sp. aff. <i>procyon</i> .	12. } Horizon of 11. } <i>Cladiscites</i> <i>crassistriatus</i> .
LADINIO STAGE.	8. Horizon of <i>Pro-</i> <i>trachyceras Arche-</i> <i>laus</i> .			
MUSCHEL- KALK.	7. Horizon of <i>Cera-</i> <i>tites Thuilleri</i> and <i>Psychites rugifer</i> . 6. Horizon of <i>Key-</i> <i>serlingites Dieneri</i> .	7. Horizon of <i>Cera-</i> <i>tites Thuilleri</i> and <i>Psychites rugifer</i> . 6. Horizon of <i>Key-</i> <i>serlingites Dieneri</i> . 5. Horizon of <i>Sibi-</i> <i>rites Prahlada</i> .	7. Horizon of <i>Cera-</i> <i>tites Thuilleri</i> .	6. Horizon of <i>Mono-</i> <i>phyllites Confucii</i> .
LOWER TRIAS.	3. Horizon of <i>Hed-</i> <i>enstrœmia Mojs-</i> <i>isovici</i> and <i>Flemingites Roh-</i> <i>illa</i> . 2. Horizon of <i>Meek-</i> <i>oceras Varaha</i> . 1. Horizon of <i>Oto-</i> <i>ceras Woodwardi</i> .	3. Horizon of <i>Hed-</i> <i>enstrœmia Mojs-</i> <i>isovici</i> and <i>Flem.</i> <i>Rohilla</i> . 2. Horizon of <i>Meek-</i> <i>oceras Markhami</i> . 1. Horizon of <i>Oto-</i> <i>ceras Woodwardi</i> .	4. Horizon of <i>Sibi-</i> <i>rites spiniger</i> . 3. Horizon of <i>Hed-</i> <i>enstrœmia Mojs-</i> <i>isovici</i> .	3. Horizon of <i>Meek-</i> <i>oceras Joharenes</i> .
PERMIAN	Horizon of <i>Cylo-</i> <i>lobus insignis</i> .			

The Lower Trias and Muschelkalk are developed almost equally well in Spiti and Painkhanda, but in Byans both divisions are *not* so well represented. In this area however the topmost beds contain the fauna of the *Sibirites spiniger* zone, which is probably homotaxial with that of the Upper Ceratite Limestone of the Salt Range.

In the ladinic stage a strongly marked difference in the development sets in. It is much richer in fossils and of greater thickness in Spiti than in Painkhanda, and has not yet been traced further east.

The same difference is equally prominent in the carnic deposits, which are well developed in Spiti, but are almost insignificant in Byans.

The noric deposits are divided into three sets of beds—Quartzite series, Brachiopod beds and Cephalopod beds—of which the last named are locally very rich in fossils but do not form a constant stratigraphical horizon. The lower noric beds of Byans show peculiar features, being made up of black shales of great thickness, wanting in the other districts. The upper noric beds consist everywhere of thick limestones which pass through beds of doubtful age into limestones of Middle Jurassic age, overlaid by the Upper Jurassic Spiti Shales. The base of these is marked by a very constant ferruginous oolitic layer of Kelloway age.

Dr. Diener appends to his memoir a discussion of the extension into other regions of the Indian Triassic province. He shows that the Triassic strata were deposited along the southern shore of the ancient ocean known as *Tethys*; that the fauna bears a quite distinct character which distinguishes it from those of the Mediterranean region; and that during the middle and upper Triassic periods Afghanistan was at the western limit of the province. Eastwards, on the other hand, the fauna of Himalayan type has been found in Yunnan, but that of Tongking points to a closer connection with the eastern Pacific region. To the south-east however the Indian marine Trias has been traced through the Malay Archipelago; and this region appears to have formed a connecting link between the Indian and Pacific provinces; while evidence of the extension of Himalayan elements to New Caledonia during this period has recently been obtained, so close that Dr. Diener states that "the

Trias of this island can scarcely put in a claim for being separated from the Indian Triassic province as a special faunistic district."

The memoir concludes with a brief account of the evolution of the Triassic ammonites.

PHYSICAL GEOLOGY.

28. During the year 1906 a number of glaciers in the North-West Himalaya were visited by officers of the Geological Survey and permanent marks were affixed to the rocks near their lower ends in order that observations on their secular oscillations might be made in future years.

This work was carried out at the instance of Mr. D. W. Freshfield, on behalf of the *Commission Internationale des Glaciers*, and has now been completed for the present by the demarcation of two of the glaciers descending from the Kinchinjunga Group in Sikkim. The observations recorded are published in Pt. 1 of the present volume of the *Records*. Marks have now been placed at, and plane-table plans made of, the ends of 14 glaciers, extending from Kashmir through Lahaul and Kumaon to Sikkim.

29. An interesting letter has been received from Dr. Hunter Workman giving an account of a visit in June 1908 to the Hassanabad glacier in Hunza, one of those marked by Mr. Hayden in 1906 (*Records*, Vol. XXXV, Pt. 3, p. 135). One of the boulders marked, No. 3 in Mr. Hayden's plan (op. cit. Pl. 38), had slipped down the hill some 50 or 60 feet from its former position, but Nos. 1 and 2 were *in situ*, and the inscriptions still bright and clear. Dr. Hunter Workman states that the tongue of the glacier had remained stationary since the plan was made, and had not altered appreciably in appearance.

30. Dr. A. Neve, of the C. M. S. Mission, Kashmir, has sent us some interesting notes on the Murgisthang or Mongstong glacier in the Mustagh Range, and on the Machai (or Mechoi) glacier, near the crest of the Zoji La, on the road from Srinagar to Leh. The latter is one of the most easily accessible glaciers in Kashmir, but the ice is so buried in moraines on either side that it would be difficult to find spots on which permanent marks could be placed near the tongue. Dr. Neve

thinks that there has been scarcely any change in it during the last 25 years.

31. The Khumdun glaciers are situated on the right bank of the Shayok river near its source, and were visited in 1908 and again in 1909 by Captain D. G. Oliver, I.A., accompanied on the latter occasion by Dr. T. G. Longstaff. The chief interest of these glaciers, so far as the question of secular oscillation is concerned, lies in the fact that they all descend from lateral valleys to the bed of the river, along which runs an important trade route across the Karakoram Pass into Tibet. Thus any general retreat or advance of the ice can be easily recognised. Captain Oliver gives instances of floods caused by the advances of the glaciers completely across the bed of the river, the last occasion when this happened being in 1903. The Aktash glacier also advanced in the same manner in 1905 but caused no flood as the water percolated through sand in the river bed at this point.

Dr. Neve's and Captain Oliver's notes will shortly be published in the *Records*

32. While engaged on a traverse along the plateau of the Salt Range in the Punjab, for the purpose of ascertaining the probable extension of the coal seams beneath the Nummulitic limestone, I took the opportunity of surveying and taking soundings of the four permanent lakes found on the plateau. The basins of these lakes, with the exception of the Jalar Kahar, were found to owe their origin to earth movements, that is to say, to a synclinal fold in the case of the Kabaki Kahar and to faulting in that of the Kalar and Son Sakesar Kahars respectively. The Jalar Kahar has been formed by erosion along the crest of an anticlinal fold in Carboniferous limestone. All the lakes are very shallow and none of them has any visible outlet. Their present configuration is due to irregularities in the accumulation of wind-blown 'loess,' which collects in the original depressions. A full account of the lakes is published in Pt. I of the current volume of the *Records*.

33. In a paper published in Vol. XXXVII, Pt. 3, of the *Records*, Mr. Coggin Brown brought up to date the accounts of the various eruptions of the mud volcanoes situated off the Arakan Coast that have taken place since 1893. There appears to have been a remarkable period

of quiescence between the years 1886 and 1903, similar to that noted by Mr. Mallet between 1846 and 1878, but it is not certain that the apparent falling off in activity is not due to lack of evidence of eruption. Since 1903 five eruptions have been recorded and are described by Mr. Brown, one of which resulted in the formation of a new island, off Beacon Island, on the 15th December 1906. This island was still in existence in December 1908, but a great part of it had been washed away.

ECONOMIC ENQUIRIES.

Coal.

34. The revision of the geological map of the Raniganj coal-field, undertaken in November 1908 in conjunction with a Committee appointed by the Mining and Geological Institute of India, has made fair progress, and it is hoped will soon be completed. The re-survey is being carried out on behalf of the Geological Survey Department by Mr. H. Walker, who testifies to the general accuracy of the original maps, for a long time out of print, constructed by the late Dr. W. T. Blanford in 1858-1860; only minor corrections in the boundaries along the margin of the field, where dense jungle existed in Dr. Blanford's time, being necessary. The principal additions to our knowledge of this important area have been made with respect to the underground correlation of the coal seams and the more accurate mapping of faults and dykes, in which work Mr. Walker and the Committee have received most valuable assistance from the owners and managers of the collieries, most of whom have placed their mining plans and boring records freely at their disposal.

35. A small patch of Damuda rocks at Gilhurria on the western flanks of the Rajmahal Hills, containing a seam of combustible carbonaceous shale, was examined by Mr. Stuart in the course of his examination of the area for china-clay and glass-making sands (referred to in last year's General Report) and is described in a short paper in Vol. XXXVIII, Pt. 2, of the *Records*. The occurrence is interesting, as it indicates the continuance of the Damudas of the Hura and Dhamni coal-fields beneath the trap, but the coal, which was being quarried by the natives, is of poor quality at the outcrop.

36. At the instance of the Railway Board I was deputed to visit the coal mines being worked by native owners in that part of the Punjab Salt Range which lies in the Shahpur District, as application had been made for the construction of a branch line from Dhak station on the Sind-Sagar line to the foot of the range to serve the mines. At present the mines are worked entirely from the outcrop, and no attempt has been made to form a reliable estimate of the quantity of coal available. The present output is not more than 40 or 50 tons a day, and until more capital is spent on the development and equipment of the mines, it would be premature to discuss the question of constructing a branch line to the locality, unless there is a demand for building stone from the Range sufficient to supplement the coal traffic.

I also made a traverse along the Salt Range plateau and suggested that a series of borings should be put down through the Nummulitic limestones which cover the greater part of it, in order to ascertain whether coal exists in workable quantities beneath it at the horizon at which the coal seams crop out along the southern scarp. An experimental boring at Dandot was sanctioned for the purpose of estimating the cost of carrying out this scheme, and is now in progress.

37. Reports of the discovery of coal in the valley of the Great Rangit River in Sikkim having been received, I visited the localities during my tour in that State. Several of the outcrops had been opened out sufficiently to show that the so-called coal is a dense black carbonaceous shale, so greatly crushed as to have assumed a nodular structure in which the nodules are surrounded by a thin glistening film of carbon, the appearance in bulk being that of a hard bright coal. It is so impure however that when placed on a fire it merely becomes calcined, and it will not support combustion. Some of the seams are as much as 6 feet in thickness, but none of the so-called coal is of any value as fuel.

Copper.

38. On my way to the glaciers of Kinchinjunga I also visited the localities in Sikkim at which copper ores are known to occur, and are now being actively prospected under European supervision. The conditions under which the lodes occur, especially the intense folding and dislocations to

which the rocks have been subjected, render it extremely difficult to form a definite opinion regarding the continuation of any particular occurrence of ore, but it is evident that in many cases the lodes, though perhaps originally continuous, have been broken up into a succession of small detached lenticles or pockets, and that the location of these would be a matter of great difficulty and expense. In a few instances, however, lodes of some persistence have been opened up, and may prove to be worth exploitation by modern methods.

39. Traces of copper ores in the Bundelkhand gneiss of the Gwalior State were investigated by Mr. Jones (see below, p. 113) but were found to be of no economic importance.

Engineering Questions.

40. At the request of General C. H. Powell, Commanding the Jullunder Brigade, I visited the Hill station of Dalhousie in September for the purpose of examining the sites proposed for the erection of a garrison church and other buildings. The cantonment is situated on a narrow spur known as the Balun spur which runs out to the north from the high ridges on which Dalhousie itself is built, at a considerably lower level than the civil station. This spur consists of slates which have a regular easterly dip, corresponding very closely with the slopes on the eastern side of the spur. The soil cap on this side, which is of great thickness, has therefore a constant tendency to creep downwards, as the toe of the slope is cut away by the stream at its base, and any heavy structures, either on the slope or near its crest, are liable to serious movement of their foundations. In fact every building already erected in such a position is severely cracked, and the eastern end of one of the barracks, which are exceedingly massive, had to be pulled down some years ago. These movements are, however, entirely confined to the soil cap, and all buildings erected not too near the eastern edge of the spur would be perfectly safe. Such a site was selected for the church and the other buildings to be erected.

41. In response to a request made by the Chief Engineer for Irrigation in Madras that the sites proposed for a dam on the Cauvery River in the Coimbatore District should be inspected and reported on by a geologist, Mr. H. Walker was deputed on this duty in July

1909. Five sites in all were examined, situated on a straight reach of the Cauvery between Cauveripuram and the mouth of the Bhavani River, where it is bordered on either side by hills of crystalline rocks. Mr. Walker submitted a full report to the Local Government, and was able to recommend a site about 3 miles below the village of Sanpalli as the most suitable for the project, but details of alternative sites are given, the final choice depending upon economic and engineering considerations.

Fire clay.

42. Among the clay beds at the base of the Morar group in Gwalior State a thick bed of soft white clay near Raipur G. T. S. has been extensively mined for use as whitewash, but from its composition, and from tests made by Mr. H. C. Jones, it is considered that it would make good fire bricks.

Galena.

43. Mr. H. C. Jones examined some occurrences of galena in the Gwalior State at the request of the Durbar. Mere traces of the existence of the mineral were found, as described below (p. 113).

Petroleum.

44. The Burma Oil-fields party for the field-season 1908-09 consisted of Messrs. E. H. Pascoe, G. de P. Cotter, K. A. K. Hallows, M. Stuart and Sub-Assistant S. Sethu Rama Rau.

45. At the beginning of the season Mr. E. H. Pascoe was engaged in assisting the Committee appointed to enquire into the working of the Yenangyaung oil-field. An analysis of data regarding flash-points and specific gravities supplied by the Burma Oil Co. led to the following interesting conclusions:—

- (i) That in each well the specific gravity decreases generally with the depth, especially near the surface.
- (ii) That in each oil horizon the specific gravity is generally least at the crest and increases further down the flanks of the anticline. Wells therefore near the margin of the field may be expected to yield a heavier oil at any particular horizon than those nearer the crest.

A final attempt was made to correlate the various oil sands recorded in the boring logs of the Companies engaged in the industry, but was not successful.

46. The portions of Ramri Island, off the coast of Arakan, examined were the northern area including the Minbyin oil-field (Yenandaung) and the oil-field of Ledaung.

Ramri Island.
Mr. E. H. Pascoe.

The island is evidently part of a raised archipelago and raised beaches are found all along the West coast. The rocks consist of sandstone and clays with occasional thin bands of conglomerate. Calcite is abundant locally, but selenite was not found in the portions of the island visited. From Mr. Davies' find of nummulites near Pyade, some of the rocks appear to be of Eocene age. Mr. Pascoe was no more successful than Mr. Mallet in any attempt to divide the beds into distinctive series.

In all but one or two doubtful cases, the rocks are inclined steeply or vertically, and the hypothesis which fits in best with the facts is that there are several sharp contiguous folds which have been sufficiently denuded to leave an almost uninterrupted series of steep dips. Some of the folds are very sinuous, and the direction of dip and strike may vary enormously.

Mud volcanoes, gas vents and oil seepages are found throughout the island except within a barren tract around the town of Ramri.

In the Minbyin field native workers have shewn themselves more enterprising than those at Yenangyaung, and have adopted a crude method of the rod-system used in Canada, learnt from Canadian drillers employed by the Australian and Baronga Oil Companies. The wells are cased for the first 18 to 20 feet only, and are never more than 500 feet deep. Some 200 wells have been put down here but most of these have been abandoned, less than 50 being worked at the present day. The total yield of the field amounts to something under 2 barrels (80 gallons) per day.

Between 15 and 20 wells have been drilled at Ledaung about 24 miles south of Minbyin and some are still producing oil.

47. Two areas were surveyed by Mr. Cotter—one in the Minbu district and one in the Pakokku district.

Mr. G. deP. Cotter.

In the Minbu district, sheets 111 and parts of sheets 110 and 84 L/6, Burma Survey, 1"=1 m., were geologically mapped. The Pegu beds are found

in the West of sheets 111 and 84 L/6, dipping very regu-

larly east except in the neighbourhood of Nghlaingdwin where they are disposed as an anticline. Mr. Cotter was able to differentiate the Pegu beds into three groups which grade insensibly into one another. The upper group consists of shallow water deposits with current-bedded sandstones, selenite and shallow water fossils including *Cyrena crawfurdi* and *C. khodaungensis*. In the middle group, current-bedding is uncommon, the rocks are harder, the clay beds more sharply differentiated from the sands, and the fossils belong to the "laminaria" zone. The lower group resembles the middle, but the sandstones are coarser and harder and the limestone bands slightly more frequent. A species of *Heterostegina* and a nummulite, most probably of oligocene age, were found at an oil seepage 3 miles N. N. W. of Nghlaingdwin. Another seepage occurs $3\frac{1}{2}$ miles W. S. W. of the same village. The Nghlaingdwin anticline is steeper on the west than on the east; and since it sinks rapidly southwards in the area mapped, Mr. Cotter is of opinion that it would be well worth while to examine the area to the north in sheet 84 L/5 before testing near Nghlaingdwin.

In the Pakokku district the Myaing anticline was examined and surveyed with the aid of cadastral maps on a scale of $2'' = 1$ m. The anticline, consisting of Pegu and Irrawaddy beds, resembles that of the Gwegyo hills. The crest is recognisable near Chaingzauk, but southwards has been faulted away by what Mr. Cotter considers to be probably a thrust-plane on the east. Fossils of the usual Pegu types were found together with selenite and fossil wood, the latter being fairly common in the Pegu rocks. There are many gas pools, but Mr. Cotter considers the area unpromising for oil boring on account of the contortion and faulting.

48. The following sheets of the Burma Survey $1'' = 1$ m. were mapped geologically: parts of 109 and 112, east of the Irrawaddy, the northern half of sheet 153, and the whole of 156.

Myingyan District.
Sub-Assistant Sethu
Rama Rau.

In sheet 109 the eastern boundary of the Pegu inlier of Singu was mapped for the first time on this scale, as also was the northern part of the Gwegyo anticline and the southern extremity of the Pagan fold. Cone-in-cone structure was found in many places in the northern part of the Gwegyo anticline.

In sheet 153 the rocks east of the Popa area were found to be folded into successive sharp anticlinal and synclinal folds and

consisted of Pegu strata. The crests of the anticlines usually occupy low ground, and their direction is about 40° W. of N. to 40° E. of S. Sandstones predominate over shales, and some contain many nodules of carbonised wood enclosed in pyritiferous sandstone. Fossil bands are plentiful, the commonest species being *Turritella simplex* and *T. acuticarinata*. Specimens of *Batissa* including *B. khodaungensis* were also obtained.

The country surveyed in sheets 156 and 112 (E. of the river) is that around and east of Magwe. In it was discovered the Pegu inlier of Ondwe on which a short note has already been published (*Records*, Vol. XXXVIII, Pt. 2, p. 152) and which is shortly to be tested for oil.

49. Mr. Vredenburg in a recent paper in the *Records* (Vol. XXXVIII, Pt. 3, p. 206), has called attention to the possibility of petroleum being found in Las Bela and the Mekran district, in rocks belonging to the Hinglaj series which correspond with the oil-bearing strata of Burma. The structure is favourable for the storage of petroleum in large quantities underground should it exist, and though no oil seepages occur, the presence of mud volcanoes along the crest of some of the anticlinal axes is a favourable sign.

The other minerals found in southern Baluchistan were noticed in the General Report for 1906 (*Records*, Vol. XXXVIII, Pt. 1, p. 50), and are described in greater detail in Mr. Vredenburg's paper cited above.

Road-metal and Building Stone.

50. Reference has been made in previous General Reports (*Records*, Vol. XXXIII, Pt. 2, p. 85, Vol. XXXV, Pt. 1, p. 30) to the question of an adequate supply of road-metal for Rangoon, the cost of importing such material from Bombay and Mauritius having become prohibitive in view of the rapid extension of the roads of the city and its surroundings and the great increase of traffic within the last few years. Formerly the Bombay basalt was brought in by ships in ballast and was collected at little cost to the Municipality, but the opening of direct steamship communication with foreign countries has cut off this source of supply. At the request of the Chief Engineer to the Government of Burma

Mr. P. N. Datta was deputed to examine the crystalline rocks of the Thaton District, Lower Burma, rendered accessible by the opening of the Pegu-Moulmein Railway, and his report, submitted in May 1909, shows that there is a practically inexhaustible supply of gneiss and granite to be obtained within easy reach of the line. These rocks, though perhaps not quite so durable as the Bombay basalt, will no doubt serve the purpose required at far less cost than the imported material.

51. In the General Report for 1908 (*Records*, Vol. XXXVIII, Pt. 1, p. 46) reference is made to a visit by Taungu stone quarries. Mr. G. deP. Cotter to the stone quarries of Taungu, Lower Burma, in order to advise the Public Works Department, Burma, regarding the location of a Government quarry for the supply of building stone. Mr. Cotter's report, submitted in April 1909, shows that building stone of two qualities may be obtained in large quantities from these quarries—

- (1) A yellow calcareous sandstone occurring in a bed from 200 to 300 feet thick, and extending for a mile along the strike. This is somewhat soft when freshly cut but hardens on exposure to the air.
- (2) Purple, sometimes pink, sandstone of medium grain, very slightly calcareous and considerably harder than the yellow sandstone. It occurs in layers averaging about 6 inches in thickness, but slabs of one foot thick might be obtained. Other localities in the neighbourhood were visited but the stone was found to be of inferior quality.

Salt.

52. The relics of a once flourishing salt manufacturing industry in the Myingyan District, now moribund on account of the competition of imported salt, are described by Sub-Assistant Sethu Rama Rau. The inhabitants of one village, Sagyin, even now subsist chiefly on this industry, and a few others are still engaged in it. The salt is derived from springs and causes a saline efflorescence on the surrounding soil. After saturation as far as possible by repeated moistening with the water flowing from the springs and drying, the soil is lixiviated either in large conical wicker baskets or in rows of earthen pots, and the brine evaporated over a slow fire.

Water.

53. Many applications have been received from Local Governments and private individuals during the year for advice regarding the search for artesian water in various parts of India. Where these enquiries are concerned with the great expanses of alluvium that cover the valleys of the Indus, Ganges and Brahmaputra the advice of a geologist is of little value, as the alluvial strata lie horizontally and information regarding the distribution of subsoil water can only be obtained by actual experiment, that is to say by well sinking or boring. In hilly tracts on the other hand the possibility of obtaining artesian water depends entirely on local conditions and it is not often possible to ascertain these from a small scale geological map without personal inspection of the ground. The following is a summary of the work that has been done during the year.

54. A boring was put down close to the Political Agent's house at Mastung to supply drinking water, and
Baluchistan : Mastung. was carried to a depth of 510 feet without meeting with water under sufficient pressure to bring it to the surface. The rocks passed through, judging from the samples submitted, were Siwalik clays, with a bed of loam at 410 feet, from which water rose to between 13 and 17 feet below ground level. This water was found to be slightly brackish, but it is not clear whether the brackishness was not caused by a leak in the tube at a higher level.

55. A boring put down to a depth of 410 feet near Said Hamid railway station (Kulozai) was not successful.
Kulozai. It was proposed to make another attempt near Gulistan, 8 miles further to the south, where the conditions are similar to those at Quetta, and there are some "karezes." A supply sufficient for drinking purposes might be obtained here.

56. Considerable activity has been shown by the Agricultural Department in Bengal in sinking borings in search of sub-soil water, in accordance with the recommendations of the Irrigation Commission. From a note supplied to this Department, by Mr. W. R. Gourlay, Director of Agriculture, it appears that operations have been carried on in nine districts, both north and south of the Ganges, and that several of the District Boards have purchased

Bengal : Borings for sub-soil water.

sets of tools. The wells sunk are said to have been more successful in the districts to the south of the Ganges than to the north, as the former must be sunk to a greater depth before reaching a water-bearing stratum, and, therefore, the water rushes in with greater force. On the north side the sands lie at a shallower depth, and it will probably be found advisable to sink ordinary percolation wells in this area.

57. In April 1909 the District Engineer in Muzaffarpur, and more recently the Secretary to the Government of Bengal, Irrigation Department, requested our advice regarding the putting down of a deep boring at Sitamarhi, in order to ascertain whether water under pressure does not exist in the coarse gravel beds that presumably lie at the base of the Gangetic alluvium. In view, however, of the distance of Sitamarhi from the northern edge of the plains, whence the water would be derived; the slight elevation above the plains of the beds into which the water percolates from the hills; and the poor results obtained from the Lucknow boring, 1,336 feet deep, in 1889, I was compelled to reply that I did not think the prospects sufficiently good to warrant the expenditure of a large sum of money on a deep boring. I think that the salvation of this and neighbouring districts will consist in the deepening of existing wells, or the sinking of borings through them, in order to reach deeper water-bearing strata in the alluvium, which may keep them supplied in times of drought.

58. Messrs. Balmer, Lawrie & Co. having reported that they experienced increasing difficulties in obtaining an adequate supply of water for their Paper Mills at Raniganj from the Damuda river owing to changes in its course, and that they contemplated boring for artesian water, Mr. H. Walker was deputed to examine and report on the possibilities of the project. He found that there was no prospect whatever of obtaining an artesian supply in the vicinity, and recommended the sinking of a number of bore-holes in the alluvium bordering the river, by which means a sufficient supply may be obtainable from a band of gravel underlying a bed of clay in the alluvium, which appears to have a considerable extension horizontally.

59. After many delays, due to the difficulty of finding a suitable site, the experimental boring in Gujarat with the Calyx drill, lent by the Geological

Survey Department, was at length started in the autumn of 1909, the site finally selected being near Sanand railway station, on the Ahmedabad-Wadhwan branch of the Bombay, Baroda and Central India Railway. A report on this boring has been furnished by the Engineer-in-charge, from which it appears that water was struck at a depth of about 300 feet from the surface, but not under artesian pressure. Pumping tests have proved that a discharge of about 5,000 gallons an hour is available, but the water is of inferior quality, and is not potable. In fact it is evident from the boring records that the water comes from a bed of sand in the alluvium, and is ordinary sub-soil water. It still remains to be proved, therefore, whether water under pressure can be obtained beneath the plains of Gujarat, but in places like Sanand the alluvium is probably too thick to be pierced by a boring of reasonable depth.

It is unfortunate that the site originally selected under the advice of this Department, to the north-east of Wadhwan, was found to be impracticable. Not only is the alluvium there probably much less deep than at Sanand, but there was a prospect of reaching the Tertiary strata which may underlie the alluvium, and which might have given a fair supply of artesian water.

60. At the request of the local Government, Mr. P. N. Datta visited the town of Pegu for the purpose of advising the Chief Engineer regarding the possibility of obtaining a supply of drinking water from artesian wells. Two sources had already been tapped by tube wells of 120 and 305 feet deep, respectively, at the Ice Factory in the town, and the existence of a water-bearing stratum at a depth of 580 feet had also been proved. Mr. Datta was of opinion, however, that the supply from the higher beds would not be sufficient for the town, as a considerable portion of it is taken by the Ice Factory, but if the water-bearing strata are continuous it should be possible to obtain a large supply from them, if several wells are sunk at such distances apart that they do not interfere with one another.

A trial boring for water at Shamgarh station on the Nagda-Muttra Railway proved unsuccessful, as the whole of the boring was in Deccan trap. It was thought that the trap-flow might be of small thickness, and that water might be found beneath it, but after boring to a depth of 217 feet the experiment was abandoned,

Burma : Artesian water at Pegu.

Central India : Trial boring at Shamgarh.

62. On his way to Upper Assam in November 1909, Mr. Hayden visited the tube wells at Chittagong which have been sunk by Messrs. Kilburn & Co. in accordance with the advice given by him after an inspection of the locality in 1906. In the first instance an experimental bore of 3½ inches in diameter was put down to a depth of 700 feet. Three water-bearing bands were met with, one of 10 feet thick at 165 feet, the second of 40 feet thick at 215 feet, and the third of 92 feet thick at 335 feet from the surface, respectively. Below this no more water-bearing strata were found. The water from the band at 335 feet, that from the upper layers having been blocked off, rose to 8 feet below the ground level, and pumping tests showed that a constant yield of about 1,100 gallons an hour, capable of being largely increased with a more powerful pump, could be obtained from this band. It was then decided to sink two other tube wells of 6 inches diameter each, near the original boring, and these have now been drilled, but only one has been fitted with machinery for testing the yield. This is about 9,000 gallons per hour, and it is estimated that the two six-inch wells will give an ample supply for the town, the requirements being about 300,000 gallons a day. The water is derived from Tertiary sandstones which have their outcrop in a ridge of low hills lying to the south-west of the town and is therefore under artesian conditions, though the effective head, owing to the low elevation of the outcrop, is not sufficient to force the water above the orifice of the bore hole.

63. Since the year 1906, the Public Works Department has been engaged in putting down a boring for artesian water at Jorhat in Upper Assam. Last year this boring reached a depth of 365 feet, and samples of the strata passed through were sent to this Department for determination. From these it appears that the boring has not yet reached the base of the alluvium, and no indications of water under pressure have been met with.

64. A boring was put down in the grounds of the Khalsa College at Amritsar in the hope of striking artesian water, but at a depth of 215 feet, operations were suspended through lack of funds. The boring records show that at this depth the alluvium had not been pierced, but the Principal of the College states that at 60 feet a practically unlimited

supply of water was met with, though not under pressure. The distance of Amritsar from the edge of the plains, about 50 miles, is probably too great to hold out much prospect of reaching the base of the alluvium at a reasonable depth from the surface.

65. The Government of the United Provinces has asked our advice regarding the sinking of artesian wells in the portion of Bundelkhand not occupied by Native States; but the greater part of the area specified consists either of metamorphic rocks or alluvium, while the narrow strips of Vindhyan rocks in the Lalitpur district are so disposed that there is no prospect of obtaining artesian water from them. It would be useless, therefore, to spend money on deep borings in this area.

66. The Department of Land Records and Agriculture in the same provinces has shown great activity in putting down shallow bore-holes as a preliminary to sinking percolation wells, with a very gratifying measure of success. During the official year ending in 1909, over 1,000 of these borings were made, and in certain cases samples of the beds passed through have been sent to this Department for determination. As a general rule, the borings are not over 100 feet in depth, being usually stopped at this point if water is not met with, and none of them appear to have been carried far enough to determine the thickness of the alluvium out in the plains.

GEOLOGICAL SURVEYS.

Aden.

67. An interesting paper has been contributed to the *Records*, Vol. XXXVIII, Pt. 4, by Captain R. E. Lloyd, I.M.S., Surgeon Naturalist, Marine Survey of India, giving the geological results of a tour made by him in 1906 through the little known country to the north of Aden. Mr. F. R. Mallet had made a short expedition through this country in 1870, but was only able to reach the foot hills and determine the presence of fossiliferous limestones there. Captain Lloyd was able to penetrate 40 miles into the hills, and ascended to Dala, which lies among hills of six or seven thousand feet in altitude. The rocks met with on the road were a sedimentary series of limestones and

sandstones and a more recent igneous series, covering a much wider area than the sedimentary rocks, and separated into :—

- (1) Massive lavas :—these occur above the others and form plateaus and pinnacles which give a characteristic appearance to the landscape ;
- (2) Horizontally bedded lavas, consisting of alternating layers of compact black lava and amygdaloidal lava ;
- (3) Beds of volcanic ashes of brightly variegated colours, dipping at pronounced angles, usually less than 30°.

It is not quite certain from Captain Lloyd's description, whether the dip of these beds is original and due to the presence of a centre of volcanic activity in this neighbourhood, or whether it is due to subsequent tectonic disturbance. As Mr. Vredenburg points out, the sedimentary rocks are similarly inclined, and he thinks therefore that there may have been a long interval between the deposition of the ash beds and the eruption of the undisturbed massive lava, which may be of quaternary age, like the Aden volcano.

The sedimentary rocks are older than the igneous series, but the uppermost beds show traces, in the presence of beds of volcanic fragments, pebbles of lava, etc., of the setting in of volcanic conditions. The limestones are highly fossiliferous and have been shown by Mr. Tipper to be of Upper Jurassic age (*see above p. 85*).

The petrology of the rocks collected by Captain Lloyd has been worked out by Mr. Vredenburg (*see above p. 85*), and the results of his investigations, with those of Mr. Tipper on the palæontology are published in separate papers in the same part of the *Records*.

Burma.

68. Part of the survey work in Burma is described above under the heading of *Petroleum*, wherever the areas dealt with have been mapped during the course of the search for new oil-fields. A considerable amount of mapping has also been carried out in other areas and a distinct advance made in the correlation and description of the Tertiary deposits.

69. In addition to the special enquiry into the suitability of the crystalline rocks of the Thatôn district for road metal, Mr. P. N. Datta made a geological survey of the western parts of the district.

**Thaton District, Lower
Burma : Mr. P. N. Datta.**

The rocks met with were :—

Alluvium.

Laterite.

Sedimentary rocks :—Sandstones and shales, more or less metamorphosed in places.

Crystalline rocks :—(i) Volcanic (probably rhyolitic); (ii) Granite and (iii) Gneiss with mica and quartz schists.

A good section of the sedimentary rocks was found in the new cuttings for the railway at Martaban Station.

Section at Martaban.

Here some of the shales are highly carbonaceous and contain plant remains, too fragmentary to admit of identification, and bivalves, with casts of what appear to be *Orhiculoidea* and the wings of insects. None of these is sufficiently well preserved or characteristic to enable the exact age of the beds to be determined, but there is no doubt that they belong to the 'Moulmein Group' of Dr. T. Oldham, and are probably of Carboniferous age.

The crystalline rocks are of ordinary types and call for no special remark, but Mr. Datta thinks that the granites and rhyolites, which were included by Mr. Theobald with the gneisses in his 'Martaban Group,' are really intrusive, and may be of post-Carboniferous age.

70. On his return from Kyaukphyu in February, Mr. Pascoe made an attempt to map the Pegu beds of Pegu beds, Yenangyaung. Yenangyaung, but found that the conditions were such that no definite boundary lines could be drawn. At Yenangyaung the Pegu beds are of a shallow water type and extremely variable in thickness, so much so that it was found impossible to recognise the divisions made by Dr. Noetling, who separated the Pegu series into a lower or Prome stage, and an upper, or Yenangyaung stage. The question is of some importance, since if horizons of definite composition could be recognized in this enormously thick series of beds, it would render the mapping of the anticlines or domes beneath which petroleum is likely to be found, and the determination of faults, a much more simple matter than it is at present. Mr. Pascoe suggests that, instead of attempting to map the various groups of beds, which are constantly changing in composition, a better method would be to lay down each outcrop observed accurately on a large scale map, and deduce the

structure of the rocks from the series of strikes thus obtained. But the chief objection to this course would be the necessity of constructing a special map (on a scale of at least 8 inches to the mile) for each locality visited.

71. As a result of surveys carried on during the final months of two field seasons around the ancient volcano of **The volcano of Popa :** Popa in the Myingyan district, more than half the **Mr. E. H. Pascoe.** area has been mapped. The northern part of the crater-wall is missing, and the rest is formed of breccia or agglomerate. There is a conspicuous parasitic cone on the west known as Taungkalat. A large part of the mountain is made of Irrawaddy sandstone, and a few small inliers of beds resembling the Pegu are observable in a few places. The oldest bed is an ashy tuff interbedded in the Irrawaddy sandstone. The lavas are mostly andesites, both hornblende and augite varieties being represented. An account of the volcano will be published as soon as the petrographical details of the rocks collected have been worked out.

72. Mr. Hallowes was engaged in examining the country immediately south of Mt. Popa. The Kyaukpadaung Hills were found to be composed of **Country south of Mt. Popa :** altered silicified tuffs, with some interbedded **Mr. K. A. K. Hallowes.** altered rhyolites, associated with pumice and volcanic agglomerate. East of Leya altered tuff and rhyolite occur interstratified with Irrawaddy sandstones. The small hill of Taungnauk between Kyaukpadaung and Popa consists of altered silicified tuffs with some interbedded rhyolitic lava flows. The junction between the Pegu and Irrawaddy series south of Popa was found to be covered by an extensive sheet of hornblende-andesite. The crater of Mt. Popa itself, according to Mr. Hallowes, lies upon a fault. The hill known as Taungni was found to be composed of altered lavas and white flour-like tuffs, some of which have been highly silicified ; it is probably an old tuff cone. Mr. Hallowes reports the discovery of tuffs interbedded in Pegu sandstones near Leya and elsewhere, indicating that volcanic activity in this area existed in pre-Pliocene times. East of the Kyaukpon hills is a large tract of Pegu rocks bent into more or less parallel anticlines striking about 30° W. of N. In these *Turritella acuticarinata* and *T. simplex* occur in great profusion. There are no good prospects of obtaining oil here.

73. The localities examined and mapped by Mr. Stuart during the season 1908-1909, were North-West Prome, Western Prome : South-West Thayetmyo, and Yenangyaung. Mr. M. Stuart. The results of these surveys have already appeared in Vol. XXXVIII, Pts. 2 and 4, of the *Records*.

The mapping made it evident that Theobald's classification of the Pegu system was the most suitable one, viz. :—

4. Kama clays.
3. Upper Prome series.
2. Lower Prome series.
1. Sitsayan shales.

and that Noetling's later suggestion to incorporate the Kama clays and the Upper Prome series into one series, which he called the Yenangyaung stage, and the Lower Prome series and Sitsayan shales into another series, which he called the Prome stage, could not be entertained.

It also became evident that the old method of classifying the fresh-water deposits as the Irrawaddy system and the underlying marine beds as the Pegu system could no longer be adopted, but that the division between the two systems must be made at the horizon of the unconformity which exists some distance below the base of the fresh-water beds. This unconformity is scarcely visible in any individual section, but on mapping the junction of the two systems is seen to be of considerable importance and extent. This brings a series of marine beds into the base of the Irrawaddy system, which series is represented in the district mapped by the beds on which the town of Prome is situated. This series of marine beds is described by Theobald as overlying the Kama clays, but is incorporated by him with the Pegu system. The Kama clays are therefore the highest beds of the Pegu system seen in the district.

It was also ascertained that there is a distinct unconformity between the base of the Pegu system (Sitsayan shales) and the Bassein system. The age of the top-most beds of the Bassein system which are seen in the district are of Eocene age.

**Classification of
Tertiary Strata.**

74. The succession in the district is therefore :—

Irrawaddy system . . .	{	Fresh-water series.
	{	Marine series.

Unconformity.

Pegu system	{ 3. Kama clays. 2. Prome beds . { Upper series. 1. Sitsayan shales. { Lower series.
-----------------------	--

Unconformity.

Bassein system.

75. Another point which was suggested by the detailed mapping of the district was that all the oil seepages in the district from the Pegu system come from the Kama clays, and that none occur in the system below this horizon. This observation is in direct conflict with Noetling's assertion that all the oil in the Pegu system comes from the Lower Prome series and Sitsayan shales (his Prome stage).

76. The structure of the Padaukpin and Banbyin area proved to be an anticline in marine Irrawaddy beds with the underlying Kama clays exposed in the crest of the anticline. Owing to the unconformity between the two systems there is not any definite anticlinal structure in the Kama clays, which are here several thousand feet thick. The marine Irrawaddy beds have a lower angle of dip in an easterly direction than the underlying Kama clays, and where the latter again crop out near Aukmancin, some ten miles to the west, only 1,200 feet of them are seen.

In view of the discovery of this structure, the fossil evidence obtained from the oil-fields of Minbu, Yenangyaung, Singu, and Yenangyat was examined and was found to favour the view that in each case the structure was similar to that of the Padaukpin-Banbyin area, and that the Pegu beds exposed in the various oil-fields were an upper development of the Kama clays.

A separate investigation was carried out on the fossil-fish teeth obtained and their evidence generally supported the above view.

Central India and Rajputana.

77. During the working season, 1908-1909, the Central India and Rajputana party was composed as last year, but with the addition of Mr. Daru. In consequence, however, of the early completion of the linking up of the recent with the older mapped regions, the

Messrs. C. S. Middle-
miss, H. C. Jones, A. M.
Heron and N. D. Daru.

portions under survey, after the first month or so, became disconnected: Messrs. Jones and Heron were drafted to Gwalior and Alwar respectively, for mineral investigations and checking of the old survey, whilst Mr. Daru continued the new survey in Partabgarh and Banswara. Mr. Middlemiss continued in charge of the party, but was only able to pay a short visit to the neighbourhood of Neemuch (North of Banswara) and to a portion of Alwar State.

78. The first two months of the season Mr. Jones spent in putting the finishing touches to his last year's mapping in the neighbourhood of Rampura in the Indore State and in parts of Jaora. This work, which connects our present survey with the old work of Messrs. Hacket and Kishen Singh, has already been summarised in some detail in last year's General Report (*Records*, Vol. XXXVIII, Pt. 1, p. 62). Nothing fresh of any importance was found in the area with the exception of a few small inliers of Delhi rocks among the Deccan Trap at Dhorwara ($24^{\circ} 13'$; $75^{\circ} 10'$) and Diknio ($24^{\circ} 10'$; $75^{\circ} 5'$), and some ancient workings for iron (magnetite and hematite of poor quality) in the Suket shales at Pardha ($24^{\circ} 32'$; $75^{\circ} 13'$).

79. The area next taken up by Mr. Jones was that of Gwalior State near Gwalior town, at those interesting localities where the Gwalior representatives of the Bijawar series are found lying unconformably above the Bundelkhand gneiss, and the Upper Vindhya's in turn unconformably above both.

The whole of this area had already been mapped on the one inch scale by Messrs. Hacket and Kishen Singh; whilst the former had also given a short but comprehensive account of its geological structure (*Records*, Vol. III, pp. 33-42, with map and further notes in *Records*, Vol. X, p. 84). The aim of Mr. Jones' visit was primarily to examine some mineral occurrences which the Gwalior Durbar was anxious to have an opinion about. Incidentally, however, a re-examination of the general geological structure of the country was undertaken, and typical specimens of all the rock series were gathered and described in more petrological detail than was previously possible. Mr. Jones' report is very full and is illustrated by numerous very clear photographs and a few local sections. Much of it, however, is a repetition of observations already made by

Hacket, expanded by further detail, and enlarged by more illustrative descriptions of local occurrences. The general stratigraphy of the area remains unchallenged. No better examples of the supposed corals (as recognised by Dr. Stoliczka) from the limestone bands of the Morar shales (see *Records*, Vol. III, p. 35) were obtained, and Mr. Jones has been unable so far to improve upon the successional arrangement of the series of limestones, traps, felsitic rocks, shales, jasper, hornstone and clay bands belonging to the Morar series, in expansion of Hacket's section given at p. 36 (*loc. cit.*). They still appear very vaguely outlined as lying generally above the Par sandstone at uncertain positions, whilst the genetic relations of many of these remarkable petrological types has not been further enquired into (compare rocks of the same age and general composition in the Son valley; *Memoirs*, Vol. XXXI, Pt. 1, pp. 58-92). The following is a brief outline of Mr. Jones' results as obtained in his examination of sheets 365, 366, 383, 399, 400, and 401 of the Central India and Rajputana topographical survey, between latitudes $25^{\circ} 45'$ and $26^{\circ} 15'$ and longitudes $78^{\circ} 0'$ and $78^{\circ} 45'$.

80. Typical Bundelkhand gneiss with pegmatites and quartz reefs, agreeing in every way with the descriptions of Mallet (unpublished reports summarised in the *Manual*, 2nd Edn., p. 27), occupy the low ground in the south-east of the area, and Mr. Jones has given a number of particular descriptions from special localities, accompanied by microscopical determinations. All appear to be varieties due to local concentration, or particular mineral segregation, of one Archæan mass that cannot be further subdivided.

81. It is in these rocks that trenches have been opened for galena at Ragonathpur ($26^{\circ} 4'$; $78^{\circ} 20'$) at Bhilowa ($26^{\circ} 3'$; $78^{\circ} 20'$) and kaolin quarries at Antri ($26^{\circ} 3'$; $78^{\circ} 17'$). Specks of galena and some pyromorphite were found in the first, but nothing at Bhilowa. Traces of galena, malachite and azurite were also found $2\frac{1}{2}$ miles west of Karhia ($25^{\circ} 54'$; $78^{\circ} 4'$).

Scarcely any metallic minerals were found in the quartz reefs penetrating the gneiss. Small specks of copper pyrites, covellite and malachite are mentioned as present, but no gold. Assays of 4 of these veins were made in the Geological Survey laboratory by Mr. Blyth without any trace of gold or silver being obtained. The

pure white variety of quartz from the reefs is used for the manufacture of glass at the Gwalior (Morar) works.

82. The trap dykes of the area, previously described by Mallet (*loc. cit.*) are identified by Mr. Jones as ophitic dolerites, consisting of pale brown augite,

Trap dykes. plagioclase felspar (labradorite), magnetite, and ilmenite frequently altered to leucoxene. Altered varieties occur containing saussuritized felspar, hornblende, epidote, quartz, chlorite and hematite.

83. A large number of notes on the Bijawar rocks of the area (Par sandstones and Morar group of shales) **Bijawar Rocks and Upper Vindhhyans.** have been put together by Mr. Jones in amplification of Hacket's original description (*Records*, Vol. III, pp. 33-42). They constitute a set of isolated petrographical descriptions of specimens and sections from many localities, but as already remarked, their mutual relations and mode of origin have not as yet been further elucidated.

84. The interbedded traps associated with the shales compose **Interbedded traps.** five main spreads, and have been determined as labradorite-augite-magnetite rocks.

85. Mr. Heron, in his new survey of Alwar State, has contributed a very carefully coloured map and detailed report, illustrated with sections and an admirable array of photographs. The area **Mr. A. M. Heron : Alwar State.** treated of is chiefly in Alwar, with portions of Jaipur and Bharatpur States, as shown in sheets 286, 287, 288, 314, 315, 316, 339 and 340 of the Central India and Rajputana topographical survey.

86. His results comprise a return to the original view of Hackett (*Records*, Vol. X, Pt. 2, p. 85) as regards the **General Results.** rock succession, a matter which requires a few words of explanation. In the above cited reference, Hackett, after surveying the area in detail, arranged the formations as below :—

Arvalis	{	Mandan group of slates, schists and quartzites ;
		Ajabgarh „ of slates, quartzites, hornstone-breccia and limestone ;
		Alwar „ of quartzites, conglomerates, schists and bedded trap ;
		Raialo „ of limestone and quartzite ;

and the small-scale map, illustrating that published report is coloured according to this scheme. Later, however, in consequence of

work in other parts of Rajputana to the west, he formally abandoned this view (*Records*, Vol. XIV, Pt. 4, p. 281) and wrote:—

“In my description of a portion of this area, the Alwar hills, in a previous paper, I placed the Ajabgarh and Mandan groups at the top of the Arvali series above the Alwar quartzites. Upon further examination of the series in the country to the west, where the sections are less broken, I found that this was not the true interpretation of the section, but that both those groups were below the quartzites, in fact, representatives of the Rajalo group. I was led into this error by the high dip of the rocks and by taking inversion for the normal sequence.

I also then included the Alwar quartzites with the Arvali series, but as in the western area the quartzites are found to constantly overlap the lower rocks; as also several cases of unconformity have been noticed it is necessary to separate these two series. As the quartzites extend up to Delhi and form the ridge there, I now propose to call the quartzites and their associates in the Mandsaur hills and elsewhere the Delhi series, retaining the name of the Alwar quartzites for the lower member of the series.”

A small-scale map illustrating the above paper is also coloured according to the new view; whilst, what is of even more importance, the signed fair copies of the large-scale, 1"=1 mile, maps handed in by Mr. Hacket in 1882, and stored now in the map cases of the department were also coloured according to this later view and indexed thus:—

Delhi series (=Alwar quartzites).

Arvali series with limestone, hornstone breccia,

and trap (=Ajabgarh series).

It should be noticed that this change of view of Hacket was made without his resurveying the Alwar area, and without his supporting it by detailed sections. His paper in Vol. XIV of the *Records* being the last published account that Hacket wrote.

87. Mr. Middlemiss, on visiting the area for a few weeks in Mr. Heron's company during the latter's survey, was particularly struck by the peculiar appearance and lie of the hornstone breccia, which both he and Mr. Heron agreed in viewing as a fault-breccia due to an *in situ* smashing and tearing asunder of the beds at various horizons near those of the Kushalgarh limestone and the Ajabgarh shales. Mr. Middlemiss, believing it to be the record of a great thrust-plane, suggested to Mr. Heron that it might possibly account for the two opposite interpretations of the sequence held by Mr. Hacket at different times. Mr. Heron, however, in his report,

Hornstone-breccia and thrust-plane.

whilst accepting the theory of it as a nearly horizontal plane of movement, does not accept this suggestion as accounting for the sequence observed, which he simply describes in full detail on the basis of the original (but since superseded) description of Hacket as given in Vol. X. of the *Records*.

Although the full petrographical descriptions of Mr. Heron are very carefully worked out, and are a distinct advance on anything hitherto attempted, it is to be hoped that further work in adjacent areas will enable Mr. Heron to clear up this question categorically.

88. Mr. Daru broke new ground in Banswara, continuing in a north and westerly direction the survey of that state already begun by Mr. Heron during the previous field season. In preparation for this he, in the first instance, spent a short time in the neighbouring state of Partabgarh, accompanying Mr. Heron in a study of the rock groups there displayed along the junction of the old work and the new.

89. Mr. Daru was able to map geologically a considerable area within sheets 175, 176, 208 and 209 of the **Area surveyed.** Central India and Rajputana topographical survey, the last two of which (begun by Mr. Heron) he has now completed.

In carrying out this he followed the delineation scheme of his predecessors as closely as possible. The outliers of Deccan Trap, which lie flatly in the usual, absolutely unconformable way above the older rocks, were continued into the newly explored ground, where they were found to occupy the higher hills and ranges. As regards the older systems, he was able to distinguish and separate from a general ground work of presumably Archæan gneisses and other crystalline rocks, a set of presumably much younger, metamorphosed sedimentary rocks, consisting of limestones, shales, slates or phyllites, garnet-quartz-biotite schists, boulder beds and schistose conglomerates. These were found to be all highly inclined or vertical as to their dip, either forming comparatively large spreads or narrow and frequently interrupted strips with a general N. 30° W.—S. 30° E. alignment.

90. In spite of the wide areas of these rocks exposed in certain parts of Banswara, both Mr. Heron and Mr. Daru found difficulty in interpreting the depositional order of the various sediments which

Difficulties of Interpretation.

compose them. Their outcrops are certainly not wanting in continuity and parallelism over considerable tracts; but the chief difficulty seems to be their obscure junctions with the Archæan ground-work, and their steep dips; which latter, even where they occasionally give rise to anticlinal and synclinal flexures, nevertheless cause the younger series to appear as a whole more like parallel packets of strata thrust on edge amongst the Archæans than like outliers resting upon the same. Mr. Daru is disposed to accept a descending order agreeing with that given in the preceding paragraph, with the exception that the limestone bands appear at varying horizons.

91. Notwithstanding this, Messrs. Heron and Daru's work taken together comprises a detailed descriptive account and large-scale map covering their joint area which now become of value in discussing questions of correlation. The younger metamorphic series as a whole, and certainly as regards its larger spreads, must now be regarded as identical with the great group which has been classified by Hacket as Aravallis, and mapped by him in the sheets a little way to the north of the area now dealt with. It would also seem to be likely that the interrupted bands of crystalline limestone, quartzite, limonite-quartz rock, grünerite rock, etc., which appear in very narrow outcrops among the wide area of mixed gneisses, and which were last year temporarily included with the mixed gneisses, should also be considered as long extended outcrops connected with the younger series rather than with the older Archæan complex—or as outcrops owing their narrow interrupted state to the circumstance that they are the remnants of almost obliterated troughs of compressed folds. This last explanation at all events seems to be the only one capable of accounting for the very elongated strip of the Masania conglomerate ($23^{\circ} 57'$; $74^{\circ} 34'$) which continues for many miles with a very narrow outcrop as an isolated band among the gneisses.

92. The conglomerate mentioned above is composed of flattened lenses of quartz held together by an argillaceous, chloritic or sericitic cement, and roughly resembling augen-structure; but another much coarser conglomerate or boulder bed, which Mr. Daru now thinks distinct from the former, is of considerable interest. It occurs prominently at Loaria ($23^{\circ} 46'$; $74^{\circ} 10'$) and resembles that from Kusalgarh described by Mr. Heron, having a matrix of biotite schist,

and contained boulders ranging up to the size of three times a man's head. These are subangular in shape, and consist of granite, gneiss, syenite and fragments of quartz, of felspar and of biotite rock. This remarkable bed is in direct connection with the schists and phyllites of one of the larger spreads of the younger metamorphic series.

93. A boulder bed of the above nature, so aggressively significant of all that can be implied by a great unconformity, is nevertheless at variance with the peculiar position of the whole series, smothered as it appears to be by the surrounding gneissic system, and also at variance with other evidence of intrusive action both of quartz veins and granite among many members of the series. We are herein reminded of the similar paradoxical relations subsisting between the Dharwars and massive gneisses of South India, a resemblance which may even not be without value as an index of age.

In view of the position suggested by Mr. Daru for the conglomerate and boulder bed among the younger metamorphic Aravallis, it is difficult to correlate it with the somewhat similar boulder bed near Udaipur to the north. The latter is said to occur doubtfully at the base of the Alwar quartzite and between it and the older schists. (C. A. Hacket, MS. Report, 1886, quoted in the *Manual*, 2nd Edn., p. 68.)

94. Both Mr. Heron and Mr. Daru have, in addition to the above, recorded some compact quartzites and schists which they cannot definitely assign to the younger (Aravalli) series; whilst at the same time they consider them as unlikely to belong to the still newer Delhi series of Hacket. In these cases, as in all those involving narrow strips of rock types isolated by want of exposures or by alluvium, the coincidence of strike that obtains throughout all the rock complexes below the Deccan Trap, renders the sorting of every known outcrop exceedingly difficult.

95. No attempt was made to limit by definite boundaries and colours on the map the various members of the Archæan complex. Archæan system among themselves. In this matter Messrs. Heron and Daru have both been compelled to follow the only feasible plan of indicating by one or two signs superposed on one uniform wash of colour such marked lithological types

as massive acid and basic intrusions, wherever such could be distinguished as exercising a predominating effect in the field. Thus the mixed gneisses are left in possession of the greater part of the area coloured Archæan, with here and there patches of granite, syenite, aplite, pegmatite and basic dyke rocks. This, though a superficial method, and one giving no clue to the genetic relationships of the rock masses to one another, is nevertheless a slight advance on the work of the older survey in neighbouring parts; but it would be premature at present to attempt any closer descriptive summary of results. This rock group may undoubtedly, as a whole, be correlated with the "gneiss" of Hacket in the area of the Aravalli Range to the north.

Punjab.

96. In continuation of his survey of the ossiferous deposits of India, Dr. G. E. Pilgrim visited that portion of the Punjab, lying between the Jhelum and the Indus, known as the Potwar, the Salt Range and the Murree Hills. Sub-Assistant M. Vinayak Rao was employed in collecting from the same district under Dr. Pilgrim's direction.

As the result of his investigations, Dr. Pilgrim has been able to arrive at certain definite and important conclusions regarding the divisions of the Tertiary fresh-water strata of the Punjab, and their correlation with the Siwalik formation in other parts of India.

A full summary of these conclusions with a revised classification of the Upper Tertiaries of India will appear in this volume of the *Records*.

97. In the first place Dr. Pilgrim shows that the nummulites associated with the mammalian fauna of Fateh-jang, near Rawalpindi, which led Lydekker to refer these beds to the eocene (Khirthar) period are not *in situ*, and that great unconformity really exists between these beds and the Khirthars. The presence of *Anthracotherium bugtiense*, *Brachyodus africanus*, and other Upper Nari forms, clearly denotes the age of these beds, which are identified with the Kuldana series of Middlemiss, and pass upwards into the Murree sandstones. These latter beds thin out rapidly towards the south and are not represented in the Salt Range, where the Kuldana beds

are followed by a series of beds correlated with the lower Siwaliks of Sind and the Bugti Hills.

98. One of the most important discoveries made by Dr. Pilgrim is the fact that the collections made by Mr. Theobald in the Potwar, from beds supposed to be on the same horizon as those mentioned above, really belong to a horizon some 5,000 to 8,000 feet higher in the series. This fauna, to which Dr. Pilgrim restricts the term Middle Siwalik, is quite distinct from the lower one, the most striking features being the absence of *Dinotherium* and the abundance of *Hipparion*, Giraffoids and the large antelopes. Furthermore, Dr. Pilgrim has proved the passage of these Middle Siwaliks upwards into beds containing a fauna identical with that of the Siwalik hills in the typical area. These latter beds had been traced by Medlicott and Theobald in practical stratigraphic continuity through Jamu and Kangra as far as the Pabbi Hills on the east side of the Jhelum, so that it now becomes possible to correlate the Siwaliks of the Siwalik Hills with the Upper Tertiaries of Western India.

99. Dr. Pilgrim also paid a visit to the Siwalik Hills in order to investigate a supposed bone deposit. This turned out to be merely a deposit of calcareous tufa; but he was able to revisit several of the old localities, which appear to have been worked out by former collectors, and discovered the important fact that most if not all of these localities are near the top of the series. The whole series of beds form a perfectly conformable sequence, and the occurrence of *Dinotherium* and species identical with those of the lower Siwaliks of the Salt Range shows that lower horizons are also represented. This is the so-called Nahan stage. With the exception of these lowest beds, the rest of the series, including both Mr. Middlemiss 'Siwalik conglomerate' and 'sand-rock' stages, corresponds both in thickness and lithological character with the Upper Siwaliks of the Pabbi Hills. The conclusion is therefore drawn that the middle Siwalik stage in the Siwalik Hills was characterised by a remarkably slow deposition, only a few hundred feet representing the 6,000 feet or so of the fossiliferous Middle Siwaliks of the Salt Range.

No reason whatever has been seen to doubt the propriety of separating the Dagshai and Kasauli series from the Nahans, or the identity of the two former with the Murree series of the Punjab.

Kashmir.

100. During the summer of 1909, Mr. Middlemiss revisited Kashmir, and added considerably to the discoveries made the previous year, which have been described in Vol. XXXVII, Pt. 4, of the *Records* and in the General Report for the year, Vol. XXXVIII, Pt. 1, p. 69. A full account of these later observations will appear in the current volume of the *Records*.

The area examined is a compact one, about 36 miles long by 16 miles broad, lying to the south-east of Srinagar, embracing the area in the Vihi district examined in detail last year and sections along the Patarkul, Traal, Lidar, Arpat and Naubug valleys, which, with a north-east—south-west trend, join the Jhelum valley above Srinagar.

In his progress through this area, Mr. Middlemiss soon found that the old interpretation of the geological series as formulated by Lydekker (*Memoirs*, Vol. XXII) needed much revision as a sequel to the more recent detailed surveys, which since Lydekker's time have been made of the Tibetan watershed of Garhwal and Kumaun, and in Spiti. A new map was therefore produced of this very typical area, and a re-grouping of the fossiliferous marine sedimentary series from Silurian to Upper Trias was instituted.

101. A large and characteristic collection of fossils was made from many of the horizons as given in the table of formations below (arranged in descending order):—

- | | | | |
|--|---|---|--|
| (12) U. TRIAS | . | . | (not differentiated into sub-zones). |
| (11) MUSCHELKALK | . | { | <i>Ptychites</i> horizon. |
| | | { | <i>Gymnites</i> do. |
| | | { | Nodular limestone. |
| (10) L. TRIAS | . | . | { <i>Meekoceras</i> horizon. |
| | | . | { <i>Ophiceras</i> do. |
| (9) ZEWAN OR | | { | <i>Spirifer Rajah</i> and <i>Marginifera</i> beds. |
| CARBONIFEROUS | . | { | <i>Protoretetpora</i> limestone and shales. |
| (8) L. GONDWANAS | . | . | { <i>Glossopteris</i> horizon (Karharbari ?) |
| | | . | { <i>Gangamopteris</i> do. (Talchir ?) |
| (7) VOLCANIC FLOWS. | | | |
| (6) AGGLOMERATIC SLATE SERIES. | | | |
| (5) M. CARBONIFEROUS (?) <i>Fenestella</i> series. | | | |

- (4) L. CARBONIFEROUS. *Syringothyris* limestone series.
 (3) MUTH QUARTZITE.
 (2) U. SILURIAN. *Orthis* shales.
 (1) L. SILURIAN AND (traces of fossils only).
 CAMBRIAN ?

Of these, the horizons of the Upper Silurian and Muschelkalk, for the first time during this visit, were identified by beds containing abundant faunas and arranged in regular sequence with the other formations round an elongated anticlinal axis which pitches to the North-West in the neighbourhood of the Lidar valley.

102. Incidentally it will be observed that the removal of the so-called Panjal traps and conglomerates of Lydekker (Nos. 7 and 6 of the table) from a low position among the (?) Silurians of that author to a much higher level, immediately below the Permo-Carboniferous and Lower Gondwanas, has been found to be necessary, as was tentatively announced in the account of the previous season's work on the Lidar valley sequence (*op. cit.*, Vol. XXXVII, p. 322).

THE MINERAL PRODUCTION OF INDIA DURING 1909. BY
T. H. D. LA TOUCHE, B.A., F.G.S., *Offg. Director,*
Geological Survey of India.

CONTENTS:

I.—INTRODUCTION—	PAGE
Total value of production. Mineral concessions granted	123
II.—MINERALS OF GROUP I—	
Chromite ; Coal ; Diamonds ; Gold ; Graphite ; Iron-ore ; Jadeite ; Magnesite ; Manganese-ore ; Mica ; Petroleum ; Ruby, Sapphire and Spinel ; Salt ; Saltpetre ; Silver-lead ore ; Tin-ore	125
III.—MINERALS OF GROUP II—	
Alum ; Amber ; Antimony ; Borax ; Building materials ; Clays ; Copper ; Corundum ; Gem stones, <i>Garnet</i> and <i>Tourmaline</i> ; Ochres ; Steatite ; Tungsten	142
IV.—MINERAL CONCESSIONS GRANTED DURING THE YEAR	146

I.—INTRODUCTION.

THE present summary of the returns of mineral production in India during 1909 covers the first year of a new quinquennial period, the returns for the five years 1904—1908 having been dealt with by Sir T. H. Holland and Dr. L. L. Fermor in the Quinquennial Review published as Vol. XXXIX of these *Records*. The arrangement adopted in the annual statements issued previous to 1908 is therefore reverted to, that is to say, the minerals are grouped in two divisions, *viz.* :—

Group I.—Those for which approximately full returns are obtainable ; and

Group II.—Those for which returns are admittedly incomplete or only approximately estimated.

One mineral, namely silver-lead ore, has been removed from Group II to Group I, for since the opening up of the silver-lead mines of Bawdwin in the Northern Shan States, more reliable figures than before are available in respect to the production of this mineral.

A summary of the total values of minerals produced in 1908 and 1909 is given in Table 1. There have again been more or less pronounced increases in the value of gold, petroleum, saltpetre and jadestone; while manganese-ore, mica, ruby, iron-ore and diamonds, the production of which had decreased in 1908, now show signs of recovery; but there was a decided drop in the value of coal, as anticipated by Sir T. Holland in his last year's statement, due to the depression in trade that followed the extraordinary activity of the years 1906—1908. While the sharp drop in the value of magnesite, from £2,009 in 1908 to £196 in 1909, again demonstrates how precarious is the demand for such minerals and how quickly they respond to changes in the European market. Salt, graphite, chromite, tin-ore, and amber have also suffered a decrease.

TABLE 1.—*Total Value of Minerals for which Returns of Production are available for the years 1908 and 1909.*

MINERALS.	1908.	1909.
	£	* £
Gold	2,177,847	2,204,866
Coal	3,356,209	2,779,865
Manganese-ore (a) *	498,269	508,483
Petroleum	702,009	910,172
Salt (b)	522,794	453,630
Saltpetre (a)	292,758	296,838
Mica (a)	139,513	156,199
Ruby, Sapphire and Spinel	47,954	58,649
Jadestone (a)	74,402	81,450
Graphite	14,365	12,529
Iron-ore (c)	15,149	16,563
Tin-ore	11,015	9,645
Chromite	6,338	5,767†
Diamonds	940	1,089
Magnesite (d)	2,009	196
Amber	364	287
TOTAL	7,861,935	7,499,228

(a) Export values. (b) Prices without duty. (c) Estimated values for provinces other than Bengal. (d) Estimated values.

* Exclusive of exports from Murmugao.

† Exclusive of the value of the output from Mysore.

The net result is that for the first time since these statistics have been published in the *Records*, there has been a drop in the

total value of mineral production, from £7,861,935 in 1908 to £7,499,228 in 1909, a decrease of 4·6 per cent. It must be observed, however, that this fall in value does not denote any serious diminution in the activity displayed in exploiting the mineral resources of the country, for it was the over-speculation of the previous years that caused the abnormal production of coal, the mineral mainly responsible for the decrease, in 1908, leaving huge stocks to be disposed of in the next year when, as a natural result, the average price per ton fell from Rs. 3·15 to Rs. 3·8.

There was a considerable drop in the total number of mineral concessions granted from 816 in 1908 to 693 during the year under review; but there was a very great increase in the number of mining leases, the figures being 71 and 156, respectively. The satisfactory aspect of this increase, however, which might be taken to mean that the activity shown in prospecting operations throughout the whole of India during previous years is resulting in a permanent expansion of the mining industry, is somewhat discounted on analysing the figures. For no less than 95 of these leases have been granted in a single province, Baluchistan, and 76 of these are for chromite alone, while it seems hardly possible that with the limited demand that exists for this mineral, every one of these ventures should become a financial success. If we omit the figures for Baluchistan the number of leases granted in other provinces indicates a no more than normal development of the industry.

II.—MINERALS OF GROUP I.

Chromite . . .	Graphite . . .	Manganese-ore . . .	Salt.
Coal . . .	Iron-ore . . .	Mica . . .	Saltpetre.
Diamonds . . .	Jadeite . . .	Petroleum . . .	Silver-lead ore
Gold . . .	Magnesite . . .	Ruby, Sapphire and Spinel.	Tin-ore.

Chromite.

The output of chromite in Mysore during 1909 amount to 4,925 tons, as against 610 tons in 1908. The value has not been reported. In Baluchistan the output for 1909 amounted to 4,325 tons, valued at £5,767, as against 4,135 tons, valued at £5,513, in 1908. The average production for the five preceding years was 4,418 tons.

PROVINCE.	Average price per ton.
	<i>Rs. a. p.</i>
Assam	4 12 0
Bengal	3 4 0
Rajputana (Bikaner)	3 6 0
Central India	3 9 0
Punjab	7 15 0
Baluchistan	10 12 0
Central Provinces	4 9 0
Nizam's Territory	6 4 0
Others	5 0 0

The production of coal in the various provinces of India is shown in Table 3. It will be noticed that Bengal shows the largest reduction, the fluctuations in the other provinces being unimportant, and practically balancing each other.

TABLE 3.—*Provincial Production of Coal during the years 1908 and 1909.*

PROVINCE.	1908.	1909.	Increase.	Decrease.
	Tons.	Tons.	Tons.	Tons.
Baluchistan	45,212	52,449	7,237	..
Bengal	11,559,911	10,660,811	..	899,100
Central India	155,107	121,496	..	33,611
Central Provinces	213,789	238,100	24,311	..
Eastern Bengal and Assam	275,224	305,563	30,339	..
Hyderabad	444,211	442,892	..	1,319
North West Frontier Province	90	96	6	..
Punjab	54,794	37,208	..	17,586
Rajputana (Bikanir)	21,297	11,449	..	9,848
TOTAL	12,769,635	11,870,064	61,893	961,464

Tables 4, 5 and 6 classify the production according to the geological formation worked. In spite of the reduced output in Bengal, where all the coal raised comes from the Gondwana system, the proportion of this coal to that from the Tertiary formations remains nearly the same as before, namely 96·57 to 3·43, in place of 96·9 to 3·1 per cent. All the coal-fields of Bengal participated in the reduction, except the little Rajmahal field, which increased its output from 333 to 1,900 tons, but the Jherria field still heads the list, with an output of 5,832,672 tons, and accounts for practically half of the Indian total. A new field, the Rangarh-Bokaro, in Chota Nagpur, one of the outlying fields surveyed many years ago by the late Mr. T. W. H. Hughes, is now being opened up and figures for the first time in these returns. In the Central Provinces the recently opened Bellarpur field has increased its output by 88 per cent., and there has also been an increase of nearly 26 per cent. at Mohpani, but the Pench Valley field shows some falling off.

TABLE 4.—*Origin of Indian Coal raised during 1908 and 1909.*

	Average of preceding five years.	1908.	1909.
	Tons.	Tons.	Tons.
From Gondwana coal-fields.	9,648,707	12,373,018	11,463,299
From Tertiary coal-fields	418,226	396,617	406,765
TOTAL . . . . .	....	12,769,635	11,870,064

TABLE 5.—*Output of Gondwana Coal-fields for the years 1908 and 1909.*

COAL-FIELDS.	1908.		1909.	
	Tons.	Per cent. of Indian total.	Tons.	Per cent. of Indian total.
<i>Bengal—</i>				
Daltonganj	96,391	76	84,290	71
Giridih	782,763	613	704,593	593
Jherria	6,458,643	5058	5,832,672	4914
Rajmahal	333	..	1,900	..
Raigarh-Bokaro . . . . .	..	..	2,544	..
Raniganj	4,221,781	3306	4,034,812	3399
<i>Central India—</i>				
Umria	155,107	122	121,496	102
<i>Central Provinces—</i>				
Bellarpur	45,299	35	85,237	72
Pench Valley	120,249	94	92,196	77
Mohpani	48,241	38	60,667	51
<i>Hyderabad—</i>				
Singareni	444,211	348	442,892	374
TOTAL	12,373,018	9690	11,463,299	9657

The Tertiary coal-fields call for no special remark except in the case of the Salt Range collieries, where there has been a decided falling off, especially in the Shahpur field. This is only what might have been expected in view of the unscientific methods by which the deposits are worked. So long as mere grubbing at the outcrop is practised, each hole being abandoned, either as soon as the coal catches fire,

which it is very apt to do spontaneously in shallow workings on account of the exposure to the atmosphere of the pyrites associated with it, or from other difficulties, there is no prospect of the industry being placed on a sound footing. The seam, which is very variable in thickness, has so far only been worked along the southern scarp of the Range, and no attempt has been made to ascertain whether it extends beneath the limestone of the plateau to the north of the scarp, where it is quite possible that large stores of coal are concealed. Its existence can only be proved by boring, and a scheme is now being discussed for a thorough exploration of the plateau by this means.

The fluctuations in the output of these Tertiary coal-fields is due partly to the generally inferior character of the coal as compared with Gondwana coal, except perhaps in the case of Assam, and partly to the fact that it is mainly raised for local purposes only, and has no large or well established market. This is especially the case in Bikanir, where much difficulty has been experienced in utilising the coal on the railways.

TABLE 6.—*Output of Tertiary Coal-fields for the years 1908 and 1909.*

COAL-FIELDS.	1908.		1909.	
	Tons.	Per cent. of Indian total.	Tons.	Per cent. of Indian total.
<i>Baluchistan—</i>				
Khost	31,547	25	40,237	34
Sor Range, Mach, etc. . .	13,665	10	12,212	10
<i>Eastern Bengal and Assam—</i>				
Makum	275,224	215	305,563	257
<i>North West Frontier Province—</i>				
Hazara	90	43	96	32
<i>Punjab (Salt Range)—</i>				
Jhelum District	41,407		34,135	
Mianwali	702		45	
Shahpur	12,685		3,028	
<i>Rajputana—</i>				
Bikanir	21,297	17	11,449	10
TOTAL	396,617	310	406,765	343

There was a slight further drop in the exports of Indian coal and coke during the period under review, **Exports and Imports.** from 659,594 tons, valued at £382,369, in 1908, to 563,940 tons, valued at £338,395, in 1909. The destination of this coal is shown in Table 7.

TABLE 7.—*Exports of Indian Coal.*

	1908.	1909.
	Tons.	Tons.
Aden	11,224	3,460
Ceylon	424,060	312,507
Straits Settlements	108,608	128,371
Sumatra	97,484	79,394
East Africa	2,658	..
Other countries	13,440	38,822
TOTAL	657,474	562,554
Coke	2,120	1,386
TOTAL of Coal and Coke	659,594	563,940

The imports of coal and coke during the same period are shown in Table 8. These do not seem to have been affected by the over-production of previous years, but show a distinct rise except in the case of Australia, where the output was restricted owing to labour troubles.

The total consumption of coal, coke and patent fuel in India amounted to 11,796,545 tons in 1909 as against **Consumption of coal.** 12,515,644 tons in 1908, but the ratio of the quantity of coal consumed with respect to the total Indian production rose from 94·8 to 95·3 per cent. The quantity of coal

TABLE 8.—*Imports of Coal, Coke and Patent Fuel during 1908 and 1909.*

	1908.	1909.
	Tons.	Tons.
From Australia (including New Zealand)	129,699	54,792
Japan	2,960	11,413
Natal	71,831	91,907
United Kingdom	156,233	290,719
Other countries	7,350	21,057
TOTAL	368,073	469,888
Coke	17,241	14,077
Patent fuel	9	6,456
Government Stores	6,198	29,567
TOTAL	391,521	519,982

consumed on Indian railways rose from 3,683,727 tons in 1908 to 3,765,314 tons in 1909, of which 3,689,093 tons were raised in India. This represents 31 per cent. of the total production of Indian coal as against 28·2 per cent. in 1908. The percentage of foreign coal consumed on the railways remained the same, *viz.*, about 2 per cent.

The statistics of labour in the Indian coal-fields were fully discussed in the *Quinquennial Review* for 1904—1908, and a brief notice therefore is all that is necessary here. The output of coal per person employed showed little change, being 99·3 tons for the total number, and 153 tons for each person employed below ground. Table 9 gives the number of persons employed in coal mining in each province, the death-rate and the output of coal for each person killed by accident. There was a decided drop in the number of accidents from 178 in 1908 to 128 in 1909, and a reduction from 1·37 to 1·07, in the rate per thousand persons employed.

TABLE 9.—Average number of Persons employed daily in the Indian Coal-fields during 1908 and 1909.

	No. of persons employed daily.		Output per person employed.	No. of deaths by accident.	Death-rate per 1,000 persons employed.	Tons of coal raised per person killed.
	1908.	1909.	1909.			
			Tons.			
Baluchistan	1,069	1,105	47·5	3	2·7	17,483
Bengal	112,219	102,253	104·3	100	0·97	10,660
Central India	1,762	1,505	80·7	1	0·66	121,496
Central Provinces	2,900	2,911	81·8	2	0·68	119,050
Eastern Bengal and Assam	1,709	1,795	171·3	12	6·69	25,463
Hyderabad	7,047	8,517	52·0	8	0·94	55,361
N. W. Frontier Province	14	4	24·0	..	..	..
Punjab	2,196	1,223	30·4	2	1·63	8,604
Rajputana	257	233	49·1	..	..	..
TOTAL	129,173	119,546	..	128	..	..
<i>Average</i>	<i>..</i>	<i>..</i>	<i>99·3</i>	<i>..</i>	<i>1·07</i>	<i>92,734</i>

Diamonds.

There was little change reported in the output of diamonds in 1909, the total productions being 147·35 carats, valued at £1,089, as against 140·75 carats, valued at £940, in 1908. But whereas in previous years the whole of the supply came from the Central Indian States, these have only produced 35·98 carats in the year under report, the balance of 111·37 carats having been obtained at Banaganpalli in the Karnul District, Madras Presidency, a diamantiferous locality reported on by Dr. W. King in 1872 (*Mem. G. S. I., Vol. VIII, p. 96, seq.*). On the other hand the value of the small output from Central India is very much higher than that from Madras, the few stones found accounting for £1,042, while the much larger quantity from Banaganpalli is valued at only £47.

The average number of persons employed daily in this industry is reported as 588 in Central India and 482 in Madras.

Labour.

Gold.

There was again a rise in the production of gold in India as shown in Table 10, but it has not yet reached the level of the early years of the last quinquennial period. The principal advance took place in Mysore, where production had been stationary for the two previous years; and there was an increased output in Burma, where the gold is obtained by dredging in the Irrawaddy at Myitkyina. All the other gold producing districts, however, show a falling off, and none appears to have been obtained in the Central Provinces, the production from which has been roughly estimated to amount to 150 ozs. annually for the previous five years.

TABLE 10.—*Quantity and Value of Gold produced in India during 1908 and 1909.*

PROVINCE.	1908.		1909.		Average No. of persons employed daily.
	Quantity.	Value.	Quantity.	Value.	
	Ounces.	£	Ounces.	£	
<i>Bombay—</i>					
<i>Dharwar</i>	7,242	27,158	5,616	21,331	1,750
<i>Burma</i>					
<i>Myitkyina</i>	7,950	30,600	8,445	32,730	} 209
<i>Katha and Pakokku</i>	150(a)	600	44	135	
<i>Hyderabad</i>	16,437	62,550	15,241	57,416	2,220
<i>Jammu and Kashmir</i> . . . . .	..	..	4	15	Not reported.
<i>Mysore</i>	535,653	2,055,567	545,309	2,092,605	Do.
<i>Punjab</i>	195	759	154	621	329
<i>United Provinces</i>	3	13	3	13	Not reported.
TOTAL	567,630	2,177,247	574,816	2,204,866	..

(a) Rough average estimate.

Graphite.

The production of graphite in Travancore State, whence the whole of the Indian output is derived, was slightly higher than in 1908, being 3,132 tons as against 2,873 tons in the former year. The value, however, shows a considerable falling off, being £12,529 in 1909 as compared with £14,365 in 1908. The average number of persons employed daily at the Travancore mines was 763 in 1909.

Iron-ore.

There was a considerable advance in the quantity of iron-ore raised in India during 1909, from 72,300 tons, valued at £15,149, in 1908, to 83,456 tons, valued at £16,563. Of the total amount, Bengal produced 72,711 tons and Burma 7,480 tons. There had been a considerable increase in the number of native furnaces worked in the Central Provinces between the years 1905 and 1908, the total rising from 276 to 626, which seems to indicate that the native smelters were making a strenuous effort to compete with imported iron, but in the year under review the number fell to 459. The shrinkage is attributed to the higher cost of labour and of working the furnaces, the payment of heavy royalties for fuel, and the competition of imported iron, though the local product is said to be superior for certain purposes.

Jadeite.

The quantity of jadeite exported from Rangoon in 1908-09, viz., 4,088 cwt., valued at £84,450, was practically the same as in 1907-08, but the price of the mineral rose from £18.59 per cwt. to £20.66 per cwt. The returns from the Myitkyina District, where the jadeite mines are situated, show that the quantity *extracted* in 1909 was only 2,487 cwt., valued at £14,892, or £6 per cwt., in spite of the fact that the right to collect the royalty was sold for a higher sum than before. The figures furnished by the licensee are probably not reliable.

Magnesite.

Only 737 tons of magnesite, valued at £196, were mined in the Salem District, Madras, as compared with 7,534 tons, valued at

£2,009, produced in 1908. The output of this mineral has been subject to severe fluctuations since the industry was started in 1902, having fallen as low as 186 tons in 1907, probably because a secure market has not yet been found.

Manganese-ore.

The returns of the production of manganese-ore are shown in Table 11. Four of the provinces show a decrease in output, but this is partially balanced by the rise in Bengal, due to the further opening up of the deposits in the Gangpur State, and in Madras, where extensive deposits are being worked in the Sandur State. Table 12 gives the production in the districts of the Central Provinces.

The exports of manganese-ore amounted to 467,276 tons as against 427,454 tons in the previous year.

Exports.

The returns for labour employed in the manganese industry are not complete. In the Central Provinces the average number of persons employed daily is reported to be 10,947; in Madras 5,451; and in Bombay 651.

Labour.

TABLE 11.—*Output of Manganese-ore for the years 1908 and 1909.*

PROVINCE.	1908.		1909.	
	Quantity.	Value. (a)	Quantity.	Value. (a)
	Tons.	£	Tons.	£
Bengal	20,000	498,269	55,000	508,483
Bombay	23,232		17,657	
Central India	13,315		10,224	
Central Provinces	431,055		381,285	
Madras	118,089		138,454	
Mysore	68,624		39,895	
TOTAL	674,315		642,675	

(a) Represents the value of exports only (*vide* Table 1).

TABLE 12.—Output of Manganese-ore in the Central Provinces during 1908 and 1909.

DISTRICT.	1908.	1909.
	Tons.	Tons.
Balaghat	135,487	134,577
Bhandara	110,673	110,856
Chhindwara	49,008	17,464
Jabalpur	48	..
Nagpur	135,839	118,388
TOTAL	431,055	381,285

Mica.

The production of mica in India during 1909 shows a considerable falling off, which has affected each of the three producing provinces, as shown in Table 13.

TABLE 13.—Production of Mica in 1908 and 1909.

PROVINCE.	<i>Average of preceding five years.</i>	1908.	1909.
	Cwt.	Cwt.	Cwt.
Bengal	23,624	36,060	22,084
Madras	12,931	11,249	8,948
Rajputana	4,664	6,234	1,871
TOTAL	41,219	53,543	32,903

Ten thousand one hundred and seven persons are returned as having been employed daily in the industry, as against 15,277 in 1908.

There was a rise in the exports of mica, from 27,572 cwt., valued at £139,513, in 1908, to 32,640 cwt., valued at £156,199, in 1909.

Exports.

Petroleum.

The output of petroleum in 1909 again surpassed all previous records, amounting to 233,678,087 gallons, an increase of 32 per cent. on the previous year. Practically the whole of the increased yield was due to greater activity in the Yenangyaung field in Upper Burma, as shown in Table 14, all the other producing districts in that province showing a decrease. In the case of the Yenangyat, Singu and Kyaukphyu fields this is said to be due to the gradual exhaustion of the oil sands, and in Akyab to the cancellation of one of the oil leases. No oil was produced in Thayetmyo during the year.

The exhaustion of the larger fields of Yenangyat and Singu is a serious matter, for it has concentrated attention on the much smaller, but as yet more productive field of Yenangyaung, where the output increased by 34 per cent.; and it is only a question of time, and that probably not very long, until this field also becomes unable to withstand the enormous drain now made upon it. In the meantime strenuous efforts are being made to discover other productive oil-fields by prospecting, but so far without complete success.

The output of the Assam oil-field shows only a slight increase, no new productive wells having been discovered in spite of active prospecting.

TABLE 14.—*Production of Petroleum during 1908 and 1909.*

	Average of previous five years.	1908.	1909.
	Gallons.	Gallons.	Gallons.
<i>Burma—</i>			
Akyab	40,101	35,667	24,758
Kyaukphyu	59,972	46,372	39,064
Magwe (Yenangyaung)	93,856,622	123,798,630	187,043,800
Myingyan (Singu)	36,530,953	43,048,948	37,169,061
Pakokku (Yenangyat)	13,094,562	6,472,545	6,119,934
Thayetmyo	552	628	<i>Nil</i>
<i>Eastern Bengal and Assam—</i>			
Digboi	2,923,359	3,243,110	3,281,750
<i>Punjab</i>	1,089	420	720
TOTAL	146,507,210	176,646,320	233,678,087

The exports of petroleum during the year declined by over 50 per cent., the quantity being 2,265,649 gallons, valued at £28,555, compared with 5,729,114 gallons, valued at £38,304 in 1908. On the other hand there was a considerable rise in the exports of paraffin wax, the figures being 144,597 cwt., valued at £225,139, against 83,572 cwt., valued at £137,288 in 1908.

The imports of kerosine oil showed a reduction of 10 million gallons as compared with those of the previous year. Table 15 gives the sources of the oil imported.

TABLE 15.—*Imports of Kerosine Oil during 1908 and 1909.*

COUNTRY OF ORIGIN.	1908.	1909.
	Gallons.	Gallons.
Borneo	8,179,838	6,970,796
Roumania	20,907,685	3,919,632
Russia	4,156,690	7,207,322
Straits Settlements	7,889,601	8,128,978
Sumatra	8,181,049	4,740,131
United States of America	31,431,505	39,547,072
Other Countries	646	448
TOTAL	80,747,014	70,514,379

The returns for labour on the oil-fields are not complete, but an average number of 3,571 persons is reported as having been employed daily on the Burmese fields.

Labour.

Ruby, Sapphire and Spinel.

The whole of the output of ruby, sapphire and spinel reported for 1909 was derived from the Burma Ruby Mines of Mogok, work at the Kashmir sapphire mines having been abandoned in 1908. The production of the Mogok mines was 205,384 carats of rubies,

13,457 carats of sapphires, and 39,463 carats of spinel, or a total of 258,304 carats, valued at £58,649, against 281,014 carats, valued at £83,505 in 1908. One thousand three hundred and eighty-five persons were employed on an average daily at the mines as compared with 1,140 in 1908.

Salt.

The production of salt during the year 1909 was somewhat less than in 1908, but is slightly higher than the average of the preceding five years. Table 16 shows the output for each province, and Table 17 the production of rock-salt in Northern India. The imports of foreign salt amounted to 460,639 tons compared with 437,887 tons in the preceding year.

TABLE 16.—*Provincial Production of Salt for the years 1908 and 1909.*

PROVINCE.	Average of previous five years.	1908.	1909.
	Tons.	Tons.	Tons.
Aden	81,996	88,324	66,535
Bengal	45	48	34
Bombay and Sind	431,100	471,302	443,707
Burma	27,145	31,336	26,944
Gwalior State	267	437	183
Madras	389,317	435,120	309,583
Northern India	319,911	341,694	408,612
TOTAL .	1,249,781	1,368,261	1,255,598

TABLE 17.—*Production of Rock-Salt during 1908 and 1909.*

MINES.	<i>Average of previous five years.</i>	1908.	1909.
	Tons.	Tons.	Tons.
Salt Range	100,839	93,774	126,987
Kohat	15,655	16,049	15,875
Mandi State	3,915	3,954	3,857
TOTAL	120,439	113,777	146,719

Saltpetre.

The quantity of saltpetre exported during 1909 was somewhat above the average for the preceding five years, being 404,946 cwt., valued at £296,838, against 358,939 cwt., valued at £265,135. The destination of the saltpetre exported is shown in Table 18.

TABLE 18.—*Distribution of Saltpetre exported during 1908 and 1909.*

EXPORTED TO	1908.		1909.	
	Quantity.	Value.	Quantity.	Value.
	Cwt.	£	Cwt.	£
China	135,396	96,950	133,382	92,735
France	14,065	9,866	28,530	19,624
United Kingdom	96,181	70,049	81,503	57,321
United States of America	77,632	70,279	84,096	73,296
Other Countries	62,922	45,614	77,435	53,862
TOTAL	386,199	292,758	404,946	296,838

Silver-lead ore.

With the completion by the Burma Mines, Ltd., of the railway to the silver-lead mines of Bawdwin in the Northern Shan States of Burma towards the close of 1908, and the erection of smelters at Mandalay, this industry has been placed on a sound footing, and both lead and silver are now being regularly shipped from Rangoon, while the statistics of production of the ore, which is now mined on a large scale in the Shan States for mixing with the refractory lead slags from Bawdwin, are now being more carefully compiled than before. Another source of supply, recently developed, is Mount Pima in the Yamethin District, the ore from which, after concentration, is sold for smelting to the Burma Mines, Ltd. The production of these ores is shown in Table 19.

The imports of lead during 1909 amounted to 6,872 tons, worth £128,036, as compared with 6,809 tons, worth £131,549 in 1908. Of this amount 3,134 tons in 1909, against 2,973 tons in 1908, were imported in the form of sheet lead for packing tea.

TABLE 19.—*Production of Silver-lead ore in Burma during 1909.*

DISTRICT.	Quantity.	BULLION SHIPPED TO LONDON.		Amount realised by sale of bullion.
		Lead.	Silver.	
		Tons.	Ounces.	
Mandalay	2	5,030	27,500	68,100
N. Shan States—				
Bawdwin	485(a)			
Namun	5,888			
S. Shan States	90	5,030	27,500	68,100
Yamethin—				
Mount Pima	2,463·5			
TOTAL	8,928·5	5,030	27,500	68,100

(a) In addition 11,850 tons of lead slag were transported from Bawdwin to the smelters at Mandalay.

Tin-ore.

The amount of tin ore produced in Burma was less than in the previous year, being 1,665 cwts. from Mergui and 7 cwts. from Tavoy, against 1,876 and 30 cwts. respectively in 1908. The figures show no material change, the average output of the preceding five years having been 1,635 cwts. One hundred persons are returned as having been employed daily on the average in the two districts.

The imports of block tin in 1909 amounted to 37,477 cwt., valued at £283,898, against 38,383 cwt., valued at £294,465 in 1908.

Imports.

III.—MINERALS OF GROUP II.

The following notes deal with those minerals for which the returns are admittedly not complete, or are only approximately estimated.

The output of alum in the Mianwali District, Punjab, was more than doubled, 4,629 cwt. having been produced in 1909, valued at £1,995, as compared with 2,204 cwt., valued at £1,000, in the previous year. This amount, however, was below the average of the preceding five years, the industry being subject to considerable fluctuations. The imports of alum were also higher, 74,419 cwt. in 1909, and 70,348 cwt. in 1908.

Alum.

Only 31 cwt. of amber are returned as having been mined in the Myitkyina District in Upper Burma, as compared with an average for the preceding five years of 104 cwt. The value is returned as £287. In 1908 the output was 49 cwt., worth £364.

Amber.

No antimony ore is returned as having been obtained during 1909 from the mine at the Shigri glacier in Labaul, referred to in the Quinquennial Review. A small quantity, 2½ tons, worth £1 a ton, is said to have been mined in the S. Shan States.

Antimony.

In the Jubbulpore district, Central Provinces, 32 tons of bauxite were extracted, valued at £12.

Bauxite.

The quantity of borax exported from India during 1909 was 5,073 cwt., valued at £6,474, as compared with an average of 4,959 cwt., valued at £6,568, for the preceding five years. None of the borax exported is produced in British India, but is brought across the frontier from Tibet.

Borax.

The most complete returns for building materials are received from Burma. The enormous rise shown in the returns for that province with respect to granite and gneiss is due to the opening of large quarries in the Thatôn District for the supply of stone to Rangoon, where extensive training works are in progress for the improvement of the port, and for use as road metal in place of the Deccan Trap formerly imported from Bombay. The Trap rock quarried in the Bassein and Ruby Mines Districts and most of the sandstone extracted is also used for metalling roads. The returns received from the various provinces are shown in Table 20.

Building materials.

The quantity of stone and marble imported during 1909 was 12,988 tons, against 13,214 tons in 1908. Bricks and tiles to the value of £79,871, were also imported, as well as 104,548 tons of cement, valued at £270,425.

Returns were received only from Burma and the Central Provinces. In Burma the amount of clay extracted was 1,123,347 tons, mainly for brick making, valued at £39,322. In the Central Provinces 10,214 tons of clay, worth £319, were extracted and 97 tons of Fuller's Earth, worth £32, used in the manufacture of pottery.

Clays.

Active prospecting operations for copper ores are still proceeding in Singbhum and Sikkim, but the concerns have not yet reached the producing stage. Seven tons of copper ore are returned as having been raised in Singbhum during the year, but the value is not given.

Copper.

The output of corundum in the Rewah State is reported as only 19 tons, valued at £103, against 36.3 tons in 1908. A small quantity, valued at £6, was also raised in Hyderabad.

Corundum.

The garnets mined in the Kishengarh State in Rajputana amounted to 384 cwt., valued at £2,884, in 1909, a considerable advance on the figures for 1908. In Ajmere only 9 cwt. were produced, valued at £97, against 32 cwt., worth £168, in 1908.

Garnet.

TABLE 20.—*Production of Building Materials in India during 1909.*

PROVINCE.	NATURE OF MATERIAL.											
	GRANITE AND GNEISS		LATERITE.		LIMESTONE.		MARBLE.		SANDSTONE.		SLATE.	
	Quantity.		Value.		Quantity.		Value.		Quantity.		Value.	
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Baluchistan . . . . .	..	..	..	..	466	815	..	..	..	..	..	..
Bengal . . . . .	..	..	..	..	42,000	1,400	..	..	..	1,518	..	..
Burma	7,733,855	465,855	302,933	20,993	104,797	11,397	..	..	316,812	9,478	26	4,281
Central India . . . . .	..	..	..	..	54,399	2,853	..	..	..	..	..	..
Central Provinces . . . . .	..	..	..	..	56,002	3,570	..	..	..	..	..	..
E. Bengal and Assam . . . . .	..	..	..	..	95,973	6,867	..	..	..	..	..	..
Madras (Coorg).	20,224	4,015	119	8	..	..	..	..	..	..	..	..
Punjab . . . . .	..	..	..	..	500	47	..	..	..	5,631	..	..
Rajputana . . . . .	..	..	..	..	29,223	3,540	1,963(a)	1,247	255	..	..	..
United Provinces . . . . .	..	..	..	..	..	..	..	..	154,945	17,861	6,143	658
TOTAL	7,754,079	469,900	303,057	21,001	383,360	37,429	1,963	1,247	472,012	27,359	13,318	4,281
Total production in 1908	357,308	22,306	247,839	25,775	410,493	30,488	1,758	1,316	175,313	18,107	Returns not complete	..
Average of preceding five years	102,132	9,323	237,453	25,997	384,708	28,236	1,718	1,462	1,25,578	19,008	..	10,751

(a) From the Makrana quarries in Jodhpur State.

The tourmaline mining industry in Upper Burma is practically extinct. In the N. Shan States seven stones are

Tourmaline. reported to have been found, valued at £26.

The yellow ochre mine at Jauli, in the Jubbulpore District, belonging to Messrs. Olpherts & Co., was not

Ochres. worked during the year. In Central India 14 tons of red ochre, valued at £3, are said to have been extracted.

The output at the steatite mines near the Marble Rocks in Jubbulpore, opened by Messrs. P. C. Dutt and

Steatite. Burn & Co. in 1907, was 564 tons, valued at £769, against 764 tons, valued at £1,019, in 1908. In Burma 4 tons were extracted in the Pakokku Hill Tracts and 14 tons in the Minbu District, the total value being returned as £477. A small quantity, valued at £11, was also obtained in Hyderabad.

The output of wolfram at Agargaon in the Nagpur District was

Tungsten. 4 cwt., and in Mergui in Lower Burma, where it is found associated with the tin ore in alluvial deposits, 140 cwt. The value of the mineral is not reported.

IV.—STATEMENT OF MINERAL CONCESSIONS GRANTED DURING 1909.

BALUCHISTAN.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Kalat .	(1) Rai Sahib Rocharam & Sons, Abbottabad.	Coal . . .	P. L. .	490	30th April 1909.	1 year.
Do. .	(2) Sirdar Bahawal Khan Satik Zai.	Do. . . .	M. L. .	160	1st July 1909	30 years.
Quetta-Pishin	(3) Babu Karam Singh, Agent of Mr. C. R. Lindsey.	Chromite . .	M. L. .	89	1st July 1908	Do.
Do. .	(4) Do. do. .	Do. . . .	M. L. .	80	Do. .	Do.
Do. .	(5) Do. do. .	Do. . . .	M. L. .	80	Do. .	Do.
Do. .	(6) Mr. W. C. Clements .	Do. . . .	M. L. .	80	1st July 1909	Do.
Do. .	(7) Mr. E. G. Foley .	Coal . . .	M. L. .	290	1st July 1908	Do.
Do. .	(8) Do. do. .	Do. . . .	P. L. .	8,960	6th May 1909	1 year.
Do. .	(9) Messrs. Alibhoy & Bros.	Do. . . .	M. L. .	80	1st January 1909.	30 years.
Do. .	(10) Messrs. E. G. Foley, W. C. Clements and Colonel A. G. Newcomen.	Do. . . .	P. L. .	3,840	21st July 1909.	1 year.
Sibi . .	(11) Colonel A. Gleadowe Newcomen, Mr. E. G. Foley and Mr. W. C. Clements.	Do. . . .	M. L. .	160	1st July 1909	30 years.
Do. . .	(12) Do. do. .	Do. . . .	M. L. .	160	Do. .	Do.
Do. . .	(13) Do. do. .	Do. . . .	M. L. .	160	Do. .	Do.
Do. . .	(14) Do. do. .	Do. . . .	M. L. .	160	Do. .	Do.
Do. . .	(15) Do. do. .	Do. . . .	M. L. .	160	Do. .	Do.
Do. . .	(16) Do. do. .	Do. . . .	M. L. .	160	Do. .	Do.
Do. . .	(17) Do. do. .	Do. . . .	M. L. .	160	Do. .	Do.
Do. . .	(18) Do. do. .	Do. . . .	M. L. .	160	Do. .	Do.
Do. . .	(19) Do. do. .	Do. . . .	M. L. .	160	Do. .	Do.
Do. . .	(20) Do. do. .	Do. . . .	M. L. .	160	Do. .	Do.
Do. . .	(21) Do. do. .	Do. . . .	M. L. .	160	Do. .	Do.
Do. . .	(22) Do. do. .	Do. . . .	M. L. .	160	Do. .	Do.
Do. . .	(23) Do. do. .	Do. . . .	M. L. .	160	Do. .	Do.
Do. . .	(24) Do. do. .	Do. . . .	M. L. .	160	Do. .	Do.

E. L. denotes Exploring License ; P.L., Prospecting License ; and M.L., Mining Lease.

BALUCHISTAN—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Sibi	(25) Colonel A. Gleadowe Newcomen, Mr. E. G. Foley and Mr. W. C. Clements.	Coal	M. L.	160	1st July 1900	30 years.
Do.	(26) Do. do.	Do.	M. L.	160	Do.	Do.
Do.	(27) Khan Bahadur Burjorji D. Patel, C.I.E.	Do.	P. L.	1,280	2nd July 1909.	1 year.
Zhob	(28) Babu Karam Singh, Agent of Mr. C. R. Lindsey.	Chromite	M. L.	80	1st July 1908	30 years.
Do.	(29) The Baluchistan Mining Syndicate.	Do.	M. L.	80	Do.	Do.
Do.	(30) Do. do.	Do.	M. L.	80	Do.	Do.
Do.	(31) Babu Karam Singh, Agent of Mr. C. R. Lindsey.	Do.	M. L.	80	Do.	Do.
Do.	(32) Mr. W. C. Clements	Do.	M. L.	80	1st July 1900	Do.
Do.	(33) Do. do.	Do.	M. L.	80	Do.	Do.
Do.	(34) Do. do.	Do.	M. L.	80	Do.	Do.
Do.	(35) Baluchistan Mining Syndicate.	Do.	M. L.	80	1st July 1908	Do.
Do.	(36) Do. do.	Do.	M. L.	160	Do.	Do.
Do.	(37) Do. do.	Do.	M. L.	80	Do.	Do.
Do.	(38) Do. do.	Do.	M. L.	80	Do.	Do.
Do.	(39) Do. do.	Do.	M. L.	80	Do.	Do.
Do.	(40) Do. do.	Do.	M. L.	80	Do.	Do.
Do.	(41) Do. do.	Do.	M. L.	240	Do.	Do.
Do.	(42) Do. do.	Do.	M. L.	240	Do.	Do.
Do.	(43) Do. do.	Do.	M. L.	132	Do.	Do.
Do.	(44) Do. do.	Do.	M. L.	80	Do.	Do.
Do.	(45) Babu Karam Singh, Agent of Mr. C. R. Lindsey.	Do.	M. L.	80	Do.	Do.
Do.	(46) Do. do.	Do.	M. L.	80	Do.	Do.
Do.	(47) The Baluchistan Mining Syndicate.	Do.	M. L.	80	Do.	Do.
Do.	(48) Do. do.	Do.	M. L.	80	Do.	Do.
Do.	(49) Do. do.	Do.	M. L.	240	Do.	Do.
Do.	(50) Do. do.	Do.	M. L.	214	Do.	Do.
Do.	(51) Babu Karam Singh, Agent of Mr. C. R. Lindsey.	Do.	M. L.	80	Do.	Do.

E. L. denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

BALUCHISTAN—*contd.*

District.	Grantee.	Minerals.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Zhob . . .	(52) Babu Faram Singh, Agent of Mr. C. R. Lindsey.	Chromite . . .	M. L. . .	80	1st July 1908	30 years.
Do. . . .	(53) The Baluchistan Mining Syndicate.	Do. . . .	M. L. . .	80	Do. . .	Do.
Do. . . .	(54) Do. do. . .	Do. . . .	M. L. . .	80	Do. . .	Do.
Do. . . .	(55) Do. do. . .	Do. . . .	M. L. . .	80	Do. . .	Do.
Do. . . .	(56) Babu Karam Singh, Agent of Mr. C. R. Lindsey.	Do. . . .	M. L. . .	80	Do. . .	Do.
Do. . . .	(57) Do. do. . .	Do. . . .	M. L. . .	80	Do. . .	Do.
Do. . . .	(58) Do. do. . .	Do. . . .	M. L. . .	80	Do. . .	Do.
Do. . . .	(59) Do. do. . .	Do. . . .	M. L. . .	80	Do. . .	Do.
Do. . . .	(60) Do. do. . .	Do. . . .	M. L. . .	80	Do. . .	Do.
Do. . . .	(61) Baluchistan Mining Syndicate.	Do. . . .	M. L. . .	80	Do. . .	Do.
Do. . . .	(62) Babu Karam Singh, Agent of Mr. C. R. Lindsey.	Do. . . .	M. L. . .	80	Do. . .	Do.
Do. . . .	(63) Do. do. . .	Do. . . .	M. L. . .	80	Do. . .	Do.
Do. . . .	(64) Do. do. . .	Do. . . .	M. L. . .	80	Do. . .	Do.
Do. . . .	(65) Do. do. . .	Do. . . .	M. L. . .	80	Do. . .	Do.
Do. . . .	(66) Do. do. . .	Do. . . .	M. L. . .	80	Do. . .	Do.
Do. . . .	(67) Do. do. . .	Do. . . .	M. L. . .	160	Do. . .	Do.
Do. . . .	(68) Do. do. . .	Do. . . .	M. L. . .	80	Do. . .	Do.
Do. . . .	(69) Do. do. . .	Do. . . .	M. L. . .	80	Do. . .	Do.
Do. . . .	(70) Do. do. . .	Do. . . .	M. L. . .	80	Do. . .	Do.
Do. . . .	(71) Do. do. . .	Do. . . .	M. L. . .	80	Do. . .	Do.
Do. . . .	(72) Do. do. . .	Do. . . .	M. L. . .	80	Do. . .	Do.
Do. . . .	(73) Do. do. . .	Do. . . .	M. L. . .	80	Do. . .	Do.
Do. . . .	(74) Do. do. . .	Do. . . .	M. L. . .	80	1st July 1908	Do.
Do. . . .	(75) Do. do. . .	Do. . . .	M. L. . .	80	Do. . .	Do.
Do. . . .	(76) Do. do. . .	Do. . . .	M. L. . .	80	Do. . .	Do.
Do. . . .	(77) Do. do. . .	Do. . . .	M. L. . .	84	Do. . .	Do.
Do. . . .	(78) Do. do. . .	Do. . . .	M. L. . .	160	Do. . .	Do.
Do. . . .	(79) Do. do. . .	Do. . . .	M. L. . .	80	Do. . .	Do.
Do. . . .	(80) Do. do. . .	Do. . . .	M. L. . .	80	1st January 1910.	Do.
Do. . . .	(81) Do. do. . .	Do. . . .	M. L. . .	82	Do. . .	Do.

E. L. denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

BALUCHISTAN—*concl'd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Zhob . .	(82) Babu Karam Singh, Agent of Mr. C. R. Lindsey.	Chromite . .	M. L. .	183	1st July 1909	30 years.
Do. . .	(83) Do. do. .	Do. . .	M. L. .	80	1st January 1910.	Do.
Do. . .	(84) Do. do. .	Do. . .	M. L. .	80	1st July 1909	Do.
Do. . .	(85) Do. do. .	Do. . .	M. L. .	80	Do. .	Do.
Do. . .	(86) Khan Bahadur Burjorjee D. Patel, C.I.E.	Do. . .	M. L. .	115	1st January 1910.	Do.
Do. . .	(87) Do. do. .	Do. . .	M. L. .	80	Do. .	Do.
Do. . .	(88) Do. do. .	Do. . .	M. L. .	80	Do. .	Do.
Do. . .	(89) Babu Karam Singh, Agent of Mr. C. R. Lindsey.	Do. . .	M. L. .	80	1st July 1909	Do.
Do. . .	(90) Do. do. .	Do. . .	M. L. .	160	Do. .	Do.
Do. . .	(91) Do. do. .	Do. . .	M. L. .	175.37	Do. .	Do.
Do. . .	(92) Do. do. .	Do. . .	M. L. .	80	Do. .	Do.
Do. . .	(93) Do. do. .	Do. . .	M. L. .	80	1st January 1910.	Do.
Do. . .	(94) Do. do. .	Do. . .	M. L. .	80	Do. .	Do.
Do. . .	(95) Do. do. .	Do. . .	M. L. .	80	Do. .	Do.
Do. . .	(96) Do. do. .	Do. . .	M. L. .	80	Do. .	Do.
Do. . .	(97) Khan Bahadur Burjorjee D. Patel, C.I.E.	Do. . .	M. L. .	80	Do. .	Do.
Do. . .	(98) Do. do. .	Do. . .	M. L. .	80	Do. .	Do.
Do. . .	(99) Do. do. .	Do. . .	M. L. .	80	Do. .	Do.

BENGAL.

Hazaribagh .	(100) S. D. Philippe, Esq.	Mica . . .	P. L. .	40	9th January 1909.	1 year.
Do. . .	(101) Messrs. Gladstone, Wylie & Co.	Minerals other than mica, coal, oil, gold, silver and precious stones.	P. L. .	1,600	28th April 1909.	Do.
Do. . .	(102) Do. do. .	Do. . .	P. L. .	400	Do. .	Do.
Do. . .	(103) Lachmi Narain Shraff.	Mica . . .	P. L. .	160	30th July 1909.	Do.
Do. . .	(104) Archibald A. C. Dickson, Esq.	Do. . .	P. L. .	100	15th July 1909.	Do.

E. L. denotes Exploring License ; P. L., Prospecting License ; and M. L., Mining Lease.

BENGAL—*contd.*

DISTRICT.	Grantee.	Mineral	Nature of grant.	Area of acres.	Date of commencement.	Term.
Hazaribagh .	(105) S. D. Philippe .	Mica . . .	P. L. .	10	8th November 1900.	1 year.
Do. .	(106) Satyendro Pado Sarker.	Do. . . .	P. L. .	300	2nd October 1900.	Do.
Sambalpur .	(107) A. H. Tietkins, Local Agent, Sambalpur.	Coal . . .	P. L. .	424.38	14th December 1900.	Do.
Singhbhum .	(108) Messrs. Martin & Co. of Calcutta.	Chromite . .	P. L. .	2,201.20	6th July 1900	Do.
Do. .	(109) Mr. P. N. Bose, Rauchi.	Gold . . .	P. L. .	2,240	30th September 1900.	2 years.
Do. .	(110) The Bengal Iron and Steel Company, Limited, 6 and 7, Clive Street, Calcutta.	Iron ore . .	M. L. .	1,920	6th December 1900.	30 years.
Do. .	(111) J. A. Joseph of Calcutta.	Manganese .	P. L. .	2,112	3rd December 1900.	1 year.

BOMBAY.

Belgaum .	(112) Mr. N. H. Patuck of Bombay.	Manganese . .	P. L. .	263	17th February 1900.	1 year.
Do. .	(113) Do. do. .	Do. . . .	E. L. .	2,238	Do. .	Do.
Do. .	(114) Mr. C. P. Boyce of Belgaum.	Do. . . .	P. L. .	1,207	21st September 1900.	Do.
Do. .	(115) Do. do. .	Do. . . .	P. L. .	102	Do. .	Do.
Gujapur .	(116) Messrs. C. Chatoorbhooj & Co., Bombay.	Asbestos . .	P. L. .	765	19th February 1900.	Do.
Do. .	(117) Mr. Shapurji China of Hyderabad (Deccan).	Gold . . .	P. L. .	1,992	4th January 1900.	Do.
Dhārwar .	(118) The Gold Fields of Dhārwar (India), Limited.	Do. . . .	M. L. .	282	1st June 1900	30 years.
Do. .	(119) The Dhārwar Gold Mines, Ltd.	Do. . . .	M. L. .	2,101	20th August 1900.	Do.
Marā .	(120) Messrs. N. Futchally & Co.	Manganese, tin, copper, chrome and naphtha.	P. L. .	2,622	19th March 1900.	1 year.
Do. .	(121) Mr. Sambshiva Iyer.	Manganese . .	P. L. .	180	18th March 1900.	Do.
Do. .	(122) Mr. C. P. Boyce .	Asbestos . .	E. L. .	20	8th November 1900.	Do.
Shiv Mahāls .	(123) Mr. F. A. H. East, Manager, Shivrājpur Syndicate.	Manganese .	M. L. .	401	26th October 1900.	30 years.

BOMBAY—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Ratnagiri .	(124) Mr. E. N. Leslie .	Mica . . .	E. L. .	2,560	15th April 1909.	1 year.
Do. .	(125) Do. do. .	Mica and coal .	P. L. .	475	Do. .	Do.
Do. .	(126) Messrs. W. Whelan Coen & Co.	Chromium . .	P. L. .	508	1st April 1909	Do.
Do. .	(127) Do. do. .	Do. . .	E. L. .	2,560	15th April 1909.	Do.
Do. .	(128) Messrs. Nansee Khairaz & Co.	Graphite, copper and gold.	P. L. .	632	27th April 1909.	Do.

BURMA.

Akyab .	(129) (1) U. Thu Taw U. (2) U. Aung Ban .	} Coal . . .	E. L. .	20,000 approximately.	8th October 1909.	1 year.
Amherst .	(130) Messrs. Foucar and Co.		P. L. (renewal)	309.14	27th June 1909.	Do.
Do. .	(131) C. Ramalingan Pillay.	Minerals . .	E. L. .	Different parts of the Amherst District in unoccupied and unreserved land belonging to Government, excluding Forest Reserves.	7th September 1909.	Do.
Bhamo .	(132) Mr. A. C. Macmillan.	Gold . . .	M. L. .	1,568	1st August 1908.	30 years.
Henzada .	(133) Mr. F. L. Phipps .	Oil . . .	P. L. .	1,920	4th March 1909.	1 year.
Do. .	(134) Bombay Burma Coal Syndicate.	Coal . . .	P. L. (renewal)	2,560	19th April 1909.	Do.
Do. .	(135) Messrs. Gillanders, Arbuthnot & Co.	Do. . .	P. L. (renewal)	2,560	Do. .	Do.
Katha .	(136) Mr. J. A. Maunon	Copper . . .	P. L. .	2,880	11th June 1909.	Do.
Lower Chindwin.	(137) Mr. W. Macdonald	Iron pyrites, sulphide of iron ore.	P. L. .	14.00	18th November 1909.	Do.
Magwe .	(138) Maung Maung Gyi.	Petroleum . .	P. L. .	383	29th March 1909.	Do.
Do. .	(139) Messrs. Finlay, Fleming & Co., Agents for the Burma Oil Co., Ltd.	Do. . .	P. L. (renewal)	12,800	1st May 1909	Do.

E. L. denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Magwe	(140) Messrs. Finlay, Fleming & Co., Agents for the Burma Oil Co., Ltd.	Petroleum .	P. L. (renewal)	1,280 acres, blocks 58. and 48.	28th April 1909.	1 year.
Do.	(141) Sulaiman Adamji .	Do. .	P. L. (renewal)	1,280 acres, blocks 58. and 68.	4th June 1909	Do.
Do.	(142) Messrs. Finlay, Fleming & Co., Agents for the Burma Oil Co., Ltd.	Do. .	M. L. .	688	1st January 1909.	30 years.
Mandalay	(143) Messrs. Bewick, Moring & Co.	Minerals of all descriptions other than mineral oil.	P. L. (renewal)	484.8	20th January 1909.	1 year.
Do.	(144) Messrs. Mower & Co.	Copper, gold, lead, silver, arsenic, and antimony.	P. L. .	2,560	8th May 1909	Do.
Do.	(145) Do. do. .	Lead, silver and copper.	P. L. .	2,560	Do. .	Do.
Do.	(146) Do. do. .	Silver and associated metals.	P. L. .	1,280 approximately.	2nd December 1909.	Do.
Meiktila	(147) Messrs. Finlay, Fleming & Co., Agents for the Burma Oil Co., Ltd.	Petroleum .	P. L. .	7,680	10th March 1909.	Do.
Do.	(148) Mr. A. Campbell-Macmillan.	Lead and copper .	P. L. .	1,280	30th June 1909.	Do.
Do.	(149) Do. do. .	Do. do. .	P. L. .	1,280	Do. .	Do.
Do.	(150) Dewalachi Galema Syndicate.	Coal .	P. L. .	2,880	25th November 1909.	Do.
Aergui	(151) Anglo-Continental Gold Syndicate.	Tin .	P. L. (renewal)	6,362.88	20th February 1909.	2 years.
Do.	(152) Mr. A. E. Laudon White, on behalf of Lieutenant-Colonel K. M. Foss.	Coal .	E. L. .	48	22nd January 1909.	1 year.
Do.	(153) Messrs. Gillanders, Arbuthnot & Co., on behalf of Mr. Hammersley Heenan.	Do. .	P. L. .	2,611.2	24th July 1909	Do.
Do.	(154) Mr. A. R. Finlay .	Tin and gold .	P. L. .	1,600	5th July 1909	Do.
Do.	(155) Do. do. .	Do. .	P. L. .	3,200	Do. .	Do.
Do.	(156) Do. do. .	Do. .	P. L. .	1,600	Do. .	Do.
Do.	(157) Do. do. .	Do. .	P. L. .	1,600	Do. .	Do.
Do.	(158) Do. do. .	Do. .	P. L. .	1,600	Do. .	Do.
Do.	(159) Do. do. .	Do. .	P. L. .	1,600	Do. .	Do.

E. L. denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Tel
Mergui .	(160) Mr. A. R. Finlay .	Tin and gold .	P. L. .	1,600	5th July 1909	1 year.
Do. .	(161) Do. do. .	Do. .	P. L. .	1,600	Do. .	Do.
Do. .	(162) Do. do. .	Do. .	P. L. .	1,600	Do. .	Do.
Minbu .	(163) Messrs. Finlay, Fleming & Co., Agents for the Burma Oil Co., Ltd.	Petroleum .	P. L. (renewal)	1,600	1st January 1909.	Do.
Do. .	(164) Do. do. .	Do. .	P. L. (renewal)	2,880	1st April 1909.	Do.
Do. .	(165) Moolla Dawood, Sons & Co.	Do. .	E. L. .	2,880	8th October 1909.	Do.
Myingyan .	(166) Messrs. J. W. Darwood & Co.	Do. .	P. L. .	320	1st February 1909.	Do.
Do. .	(167) Messrs. Finlay, Fleming & Co., Agents for the Burma Oil Co., Ltd.	Do. .	P. L. .	1,320	28th January 1909.	Do.
Do. .	(168) Messrs. A. S. Jamal Brothers & Co.	Do. .	P. L. .	640	17th February 1909.	Do.
Do. .	(169) Do. do. .	Do. .	P. L. .	1,280	Do. .	Do.
Do. .	(170) Mr. J. W. Parry .	Do. .	E. L. .	2,560	14th January 1909.	Do.
Do. .	(171) Do. do. .	Do. .	E. L. .	5,120	Do. .	Do.
Do. .	(172) Rangoon Oil Co. .	Do. .	P. L. .	640	15th February 1909.	Do.
Do. .	(173) Messrs. Finlay, Fleming & Co., Agents for the Burma Oil Co., Ltd.	Do. .	P. L. .	3,504	4th October 1908.	Do.
Do. .	(174) Do. do. .	Do. .	P. L. .	1,280	15th September 1908.	Do.
Do. .	(175) Moolla Ahmed .	Do. .	P. L. .	1,250	29th May 1909	Do.
Do. .	(176) Messrs. Finlay, Fleming & Co., Agents for the Burma Oil Co., Ltd.	Do. .	P. L. .	7,680	1st May 1909	Do.
Do. .	(177) Mr. J. W. Parry .	Do. .	E. L. .	2,560	1st November 1909.	Do.
Do. .	(178) Messrs. Finlay, Fleming & Co., Agents for the Burma Oil Co., Ltd.	Do. .	P. L. .	1,280	15th September 1909.	Do.
Myitkyina .	(179) Mr. A. R. Oberlander.	Copper, silver, iron and sulphur.	P. L. .	640	11th November 1909.	Do.
Northern Shan States.	(180) Mr. R. S. Dickie .	Lead and silver .	P. L. .	640	17th March 1909.	Do.
Do. .	(181) Burma Mines, Ltd.	Coal . . .	P. L. .	502·656	4th May 1909	Do.
Do. .	(182) Do. do. .	Lead, copper, zinc, nickel, cobalt, silver and gold.	P. L. .	312	27th May 1909.	Do.

E. L. denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Pakókku	(183) Rangoon Oil Co.	Petroleum	P. L.	1,280	7th February 1909.	1 year.
Do.	(184) Messrs. Finlay, Fleming & Co., Agents for the Burma Oil Co., Ltd.	Do.	P. L.	640	1st January 1909.	Do.
Do.	(185) Do. do.	Do.	P. L. (renewal)	2,560	9th October 1908.	Do.
Do.	(186) Maung Kyaw Zan	Do.	E. L.	Over areas near Tazu village.	14th January 1909.	Do.
Do.	(187) M. Goolam Hussein	Do.	P. L.	1,920	15th July 1909.	Do.
Do.	(188) Do. do.	Do.	P. L.	1,280	21st July 1909	Do.
Do.	(189) Maung Kyaw Zan	Do.	E. L.	Over areas near Tazu and Okhmin villages, Pauk Township.	14th June 1909.	Do.
Do.	(190) Maung Po Tha'k	Do.	M. L.	Undemarcated blocks Nos. 3 and 4.	1st September 1909.	30 years.
Do.	(191) Maung Shwe Goh	Do.	P. L.	1,280	22nd December 1909.	1 year.
Do.	(192) Messrs. Finlay, Fleming & Co., Agents for the Burma Oil Co., Ltd.	Do.	P. L.	2,240	11th November 1909.	Do.
Do.	(193) Mr. A. W. G. Bleock, on behalf of Messrs. Mower & Co.	Do.	P. L.	4,480	22nd December 1909.	Do.
Do.	(194) Maung Shwe Goh	Do.	P. L.	2,240	Do.	Do.
Do.	(195) Maung Mu	All minerals	E. L.	Saw Township	4th November 1909.	Do.
Prome	(196) Mr. W. B. E. Rule	Mineral oil	P. L.	10,496	3rd June 1909	Do.
Do.	(197) Mr. Benjamin Galloworthy.	Petroleum	P. L.	19,884·8	6th August 1909.	Do.
Sagaing	(198) Mr. S. Spencer, on behalf of the Burma Mines, Ltd.	Iron ore	P. L.	550·96	3rd August 1909.	Do.
Salween	(199) Mr. A. H. Rowland Ady.	Galena and lead	P. L.	2,560	1st July 1909	Do.
Do.	(200) Mr. G. E. Hayes	Silver and lead	P. L.	3,200	23rd September 1909.	Do.
Shwebo	(201) Mr. C. D. Clark, Manager for the Burma Mines, Ltd.	Iron	P. L.	320	1st July 1909	Do.

E. L. denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Southern Shan States.	(202) Htamong Ye and Sava Kyi.	Silver and lead .	M. L. .	738	1st June 1908	5 years.
Do.	(203) Mr. F. H. Parry, on behalf of the Dewalachi Galena Syndicate.	Lead, copper and other minerals.	P. L. .	3,200	20th June 1909.	1 year.
Do.	(204) Messrs. Mower & Co.	Wolfram . .	P. L. .	2,560	7th July 1909	Do.
Do.	(205) Mr. T. Fowle .	Copper, galena and other ores.	P. L. .	3,200	26th August 1909.	Do.
Do.	(206) Messrs. Mower & Co.	Wolfram . .	P. L. .	2,560	25th August 1909.	Do.
Do.	(207) Mr. F. H. Parry, on behalf of the Dewalachi Galena Syndicate.	Copper, etc. .	P. L. .	1,609	Do.	Do.
Tavoy .	(208) Ko Tun Byaw, Attorney of Mr. A. C. Martine, Rangoon.	Minerals of every description.	E. L. .	Whole district	31st May 1909	Do.
Do.	(209) Mr. J. W. Donaldson Aiken.	Tin, wolfram, gold and galena.	P. L. .	2,880	14th August 1909.	Do.
Do.	(210) Mr. R. B. Levien .	Tin and other minerals.	P. L. .	640	7th October 1909. .	Do.
Thahton .	(211) Mr. G. E. Hayes .	Gold and other minerals.	P. L. .	3,200	19th March 1909.	Do.
Do.	(212) Messrs. Mower & Co.	Gold, silver, copper, iron and pyrites.	P. L. .	3,200	7th April 1909	Do.
Do.	(213) Do. do. .	Silver and lead .	P. L. .	2,560	27th November 1908.	Do.
Thayetmyo .	(214) Messrs. Bawancy Brothers & Co.	Petroleum . .	E. L. .	2,560	19th April 1909.	Do.
Do.	(215) Messrs. Finlay, Fleming & Co., Agents for the Burma Oil Co., Ltd.	Do. . .	E. L. .	41,062	9th July 1909	Do.
Do.	(216) Maung Po Ni .	Do. . .	E. L. .	633	29th July 1909.	Do.
Do.	(217) Maung Tun Aung Gyaw.	Do. . .	E. L. .	2934	11th October 1909.	Do.
Do.	(218) Chiew Bah Ghone .	Do. . .	E. L. .	9,664	Do. .	Do.
Do.	(219) Maung Tun Aung Gyaw.	Do. . .	E. L. .	9,356.8	28th October 1909.	Do.
Do.	(220) Shammuddin .	Do. . .	E. L. .	8,876.8	6th November 1909.	Do.
oungoo .	(221) Mr. A. R. Ady .	Silver, lead and other metals.	P. L. .	1,349	13th March 1909.	Do.

E. L. denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

BURMA—concl'd.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Toungoo .	(222) Mr. C. E. Brown .	Silver, lead and other metals.	P. L. (renewal)	3,200	30th October 1906.	Renewed on the 23th October 1909 till 30th April 1910.
Do. .	(223) Mr. N. Samwell .	Gold . . .	E. L. (renewal)	Shwëgyin river and its tributaries on the east of the Sittang river.	19th December 1908.	Renewed for 1 year on the 20th December 1909.
Upper Chindwin.	(224) The Petroleum Syndicate, by its Manager, Major H. W. Iles.	Petroleum . .	P. L. .	5,760	26th March 1909.	1 year.
Do. .	(225) Mr. W. A. Freymuth, on behalf of the Burma Mines Development and Agency, Ltd.	Coal . . .	M. L. .	1,920	1st July 1908	30 years.

CENTRAL PROVINCES.

Akola . .	(226) Mr. Malho, son of Balkrishna Bawne.	All minerals .	E. L. .	1,920	10th July 1909	1 year.
Belaghat .	(227) Mr. D. Laxminarayan, Kamptee.	Manganese . .	M. L. .	116	18th January 1909.	30 years.
Do. .	(228) Mr. M. M. Mulha .	Do. . . .	P. L. .	120	20th March 1909.	1 year.
Do. .	(229) Mr. D. Laxminarayan.	Do. . . .	M. L. .	96	18th January 1909.	30 years.
Do. .	(230) Messrs. Lalbihari Naraindas and Ramcharan Shunkar Lall of Kamptee.	Do. . . .	P. L. .	594	5th January 1909.	1 year.
Do. .	(231) Mr. A. C. Blechyn-den.	Do. . . .	P. L. .	1,078	15th January 1909.	Do.
Do. .	(232) Lala B. Sitaran .	Do. . . .	P. L. .	323	31st March 1909.	Do.
Do. .	(233) Mr. Byramji Pestonji.	All minerals .	E. L. .	887	31st January 1909.	Do.
Do. .	(234) Babu Kripa Shanker.	Manganese . .	P. L. .	188	Do. .	Do.
Do. .	(235) Nagpur Manganese Mining Syndicate, Ltd.	Do. . . .	P. L. .	187	Do. .	Do.

E. L. denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Balaghat	(236) Mr. C. Velu Ayah .	Manganese .	P. L. .	98	29th March 1909.	1 year.
Do.	(237) Nagpur Manganese Mining Syndicate, Ltd.	All minerals .	E. L. .	766	26th March 1909.	Do.
Do.	(238) Mr. Byramji Pestonji.	Manganese .	P. L. .	212	13th May 1909.	Do.
Do.	(239) Babu Kripa Shankar.	Do. .	P. L. .	145	24th June 1909.	Do.
Do.	(240) Mr. Byramji Pestonji.	Do. .	P. L. .	70	13th May 1909.	Do.
Do.	(241) Do. do. .	All minerals .	E. L. .	3,157	24th April 1909.	Do.
Do.	(242) Babu Kripa Shankar.	Do. .	E. L. .	346	14th June 1909.	Do.
Do.	(243) Messrs. Ratanchand Kesrichand Chullany & Sons.	Manganese .	P. L. .	320	Do. .	Do.
Do.	(244) Nagpur Manganese Mining Syndicate, Ltd.	All minerals .	E. L. .	106	20th May 1909.	Do.
Do.	(245) The Central India Mining Co., Ltd.	Manganese .	P. L. .	115	30th June 1909.	Do.
Do.	(246) Babu Kripa Shankar.	All minerals .	E. L. .	518	14th June 1909.	Do.
Do.	(247) Mr. Byramji Pestonji.	Do. .	E. L. .	272	15th May 1909.	Do.
Do.	(248) Mr. S. O. Holmes .	Manganese .	P. L. .	334	16th August 1909.	Do.
Do.	(249) Mr. M. M. Mullna, Pleader, Balaghat.	Do. .	P. L. .	789	20th August 1909.	Do.
Do.	(250) Mr. C. Velu Ayah .	Do. .	P. L. .	45	23rd August 1909.	Do.
Do.	(251) Mr. Byramji Pestonji of Raipur.	Do. .	P. L. .	121	9th September 1909.	Do.
Do.	(252) Rai Saheb Mathura Prasad and Motilal of Chhindwara.	Do. .	M. L. .	13	1st July 1909	30 years.
Do.	(253) Mr. Hiralal Sukhul	Do. .	M. L. .	16	Do. .	Do.
Do.	(254) Messrs. Kassambhoy, Gopaldass and Mahadeo Seth of Kamptee.	Do. .	P. L. .	80	8th August 1909.	1 year.
Do.	(255) Babu Kripa Shankar.	Do. .	P. L. .	347	29th September 1909.	Do.
Do.	(256) Mr. Hiralal Sukhul	Do. .	M. L. .	16	9th September 1909.	30 years.

E. L. denotes Exploring License ; P. L., Prospecting License ; and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Balaghat	(257) Messrs. Ratanchand Keshichand Chullany & Sons.	All minerals	E. L.	148	11th September 1909.	1 year.
Do.	(258) The Bombay Prospecting and Mining Syndicate.	Do.	E. L.	544	18th November 1909.	Do.
Do.	(259) Mr. Byramji Pestonji.	Do.	E. L.	6,219	26th November 1909.	Do.
Do.	(260) Messrs. Schrodor, Smidt & Co.	Manganese	P. L.	52	29th October 1909.	Do.
Do.	(261) Do. do.	Do.	P. L.	1,035	Do.	Do.
Do.	(262) Do. do.	Do.	P. L.	530	8th October 1909.	Do.
Do.	(263) Messrs. Kassambhoy, Ramji & Co.	Mica	P. L.	285	2nd October 1909.	Do.
Do.	(264) Nagpur Manganese Mining Syndicate, Ltd.	All minerals	E. L.	94	16th November 1909.	Do.
Betul	(265) Rai Bahadur Ballabhdasand Kuwar Jiwandas.	Coal, copper, manganese, gold, silver and mineral oil.	P. L.	8,890	10th February 1909.	Do.
Do.	(266) Mr. Hanumanrao, Kamptee.	Graphite	P. L.	522	Do.	Do.
Do.	(267) Mr. Byramji Pestonji.	All minerals	E. L.	342	5th June 1909.	Do.
Do.	(268) Do. do.	Do.	E. L.	324	Do.	Do.
Do.	(269) Mr. P. E. Cameron	Coal	P. L.	1,874	11th September 1909.	Do.
Do.	(270) Mr. R. K. Kanga	Do.	P. L.	2,182	26th July 1909.	Do.
Do.	(271) Mr. Tricundas Cooverji.	Do.	P. L.	2,872	25th November 1909.	Do.
Do.	(272) Do. do.	Do.	P. L.	1,110	Do.	Do.
Do.	(273) Mr. Khimji Cooverji of Bombay.	Do.	P. L.	1,363	5th October 1909.	Do.
Do.	(274) Seth Lakshmi-chand.	Manganese	P. L.	148	25th October 1909.	Do.
Do.	(275) Mr. E. Nagannah Naidu.	Graphite	P. L.	88	10th November 1909.	Do.
Bhandara	(276) Babu Madhulal Dugar, Calcutta.	Manganese	P. L.	262	13th March 1909.	Do.
Do.	(277) Messrs. Lalbihari Naraindas and Raucharan Shunker Lal of Kamptee.	Do.	P. L.	847	2nd March 1909.	Do.

E. L. denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in aers.	Date of commencement.	Term.
Bhandara	(278) Mr. R. H. Richardson, Kamptee.	Manganese.	M. L.	50	12th December 1908.	30 years.
Do.	(279) Central India Mining Co., Ltd., Kamptee.	Do.	M. L.	207	10th December 1908.	Do.
Do.	(280) Diwan Bahadur Kasturehand Daga.	Do.	M. L.	176	4th February 1909.	Do.
Do.	(281) Mr. S. S. Wazalwar	Do.	P. L.	140	9th February 1909.	1 year.
Do.	(282) Messrs. Ramprasad and Laxminarayan.	Do.	P. L.	223	5th March 1909.	Do.
Do.	(283) Mr. Rambilas Murlidhar.	Do.	M. L.	143	16th January 1909.	30 years.
Do.	(284) Messrs. Jessop & Co., Calcutta.	Do.	P. L.	114	9th January 1909.	1 year.
Do.	(285) Do. do.	Do.	P. L.	249	14th February 1909.	Do.
Do.	(286) Mr. Hiralal Sukhlul	Do.	P. L.	362	9th January 1909.	Do.
Do.	(287) Mr. T. B. Kantharia.	Do.	P. L.	60	Do.	Do.
Do.	(288) Do. do.	Do.	P. L.	96	8th February 1909.	Do.
Do.	(289) Mr. Byramji Pestonji.	All minerals	E. L.	2,442	20th February 1909.	Do.
Do.	(290) Central India Mining Co., Ltd.	Manganese	M. L.	507	10th December 1908.	30 years.
Do.	(291) Do. do.	Do.	M. L.	122	Do.	Do.
Do.	(292) Messrs. Kassambhoy, Gopaldass and Mahadeo Seth, Kamptee.	Do.	P. L.	273	17th February 1909.	1 year.
Do.	(293) Mr. Vinayak Rao Valdiya.	Do.	P. L.	198	26th March 1909.	Do.
Do.	(294) Mr. Byramji Pestonji.	Do.	M. L.	47	2nd March 1909.	30 years.
Do.	(295) Messrs. P. S. Kotwal and S. R. Naidu.	Do.	P. L.	85	5th February 1909.	1 year.
Do.	(296) Mr. Bansilal Kalnr	Do.	P. L.	205	27th February 1909.	Do.
Do.	(297) Do. do.	Do.	P. L.	64	Do.	Do.
Do.	(298) Seth Jagannath	Do.	P. L.	57	26th March 1909.	Do.
Do.	(299) Messrs. Kassambhoy, Gopaldass and Mahadeo Seth.	Do.	P. L.	354	16th March 1909.	Do.

E. L. denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Bhindara	(300) Lala Bausilai Kalar	Manganese.	P. L.	299	27th February 1909.	1 year.
Do.	(301) Nagpur Manganese Mining Syndicate, Ltd.	Do.	P. L.	232	30th March 1909.	Do.
Do.	(302) Do. do.	All minerals.	E. L.	35	Do.	Do.
Do.	(303) Mr. Pyramji Pestonji.	Do.	E. L.	505	6th March 1909.	Do.
Do.	(304) Do. do.	Do.	E. L.	4,743	31st March 1909.	Do.
Do.	(305) Nagpur Manganese Mining Syndicate, Ltd.	Do.	E. L.	104	12th March 1909.	Do.
Do.	(306) Do. do.	Do.	E. L.	159	30th March 1909.	Do.
Do.	(307) Do. do.	Do.	E. L.	74	Do.	Do.
Do.	(308) Mr. H. Verma of Chhindwara.	Manganese.	P. L.	183	7th May 1909	Do.
Do.	(309) Messrs. Kassambhoy, Gopaldass and Mahadeo Seth.	Do.	P. L.	97	21st May 1909.	Do.
Do.	(310) Mr. H. Verma of Chhindwara.	Do.	P. L.	18	15th May 1909.	Do.
Do.	(311) Mr. T. B. Kautharia.	Do.	P. L.	55	21st April 1909.	Do.
Do.	(312) Mr. D. Laxminarayan.	Do.	M. L.	61	24th March 1909.	30 years
Do.	(313) Mr. R. K. Kanga	Manganese, tin, copper, wolfram, lead, graphite and silver.	P. L.	1,300	1st June 1909	1 year.
Do.	(314) Mr. R. H. Richardson.	Manganese.	M. L.	23	9th March 1909.	30 years
Do.	(315) Mr. Murdhar.	Do.	P. L.	274	8th May 1909.	1 year.
Do.	(316) Messrs. Balibhadra and Mohanlal.	Do.	P. L.	288	25th April 1909.	Do.
Do.	(317) Messrs. Kassambhoy, Gopaldass and Mahadeo Seth.	Do.	P. L.	150	16th April 1909.	Do.
Do.	(318) Messrs. Brahma Dutta Baijnath of Tumsar.	Do.	P. L.	97	14th June 1909.	Do.
Do.	(319) Messrs. Kassambhoy, Gopaldass and Mahadeo Seth.	Do.	P. L.	631	20th June 1909.	Do.
Do.	(320) Mr. P. Balkrishna Naidu.	Do.	P. L.	108	31st May 1909.	Do.

E. L. denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Bhandara	(321) Diwan Bahadur Kasturchand Daga.	Manganese.	P. L.	128	21st May 1909.	1 year.
Do.	(322) Nagpur Manganese Mining Syndicate, Ltd.	Do.	P. L.	104	26th May 1909.	Do.
Do.	(323) Messrs. B. B. B. Fouzdar Bros.	Do.	P. L.	257	4th June 1909.	Do.
Do.	(324) Messrs. Kassambhoy, Gopaldass and Mahadeo Seth.	Do.	P. L.	78	Do.	Do.
Do.	(325) Mr. E. C. Dugore	Do.	P. L.	171	11th April 1909.	Do.
Do.	(326) Nagpur Manganese Mining Syndicate, Ltd.	Do.	P. L.	15	26th May 1909.	Do.
Do.	(327) Do. do.	Do.	P. L.	35	Do.	Do.
Do.	(328) Mr. Pestonji.	Do.	P. L.	505	1st May 1909	Do.
Do.	(329) Do. do.	Do.	P. L.	193	15th June 1909.	Do.
Do.	(330) Nagpur Manganese Mining Syndicate, Ltd.	All minerals	E. L.	97	15th April 1909.	Do.
Do.	(331) Mr. E. C. Dugore	Manganese	P. L.	4	21st May 1909.	Do.
Do.	(332) Mr. Byramji Pestonji.	All minerals	E. L.	7	1st May 1909	Do.
Do.	(333) Do. do	Manganese	P. L.	93	31st May 1909.	Do.
Do.	(334) Nagpur Manganese Mining Syndicate, Ltd.	Do.	P. L.	17	26th May 1909.	Do.
Do.	(335) Mr. P. Balkrishna Naidu.	Do.	P. L.	291	31st May 1909.	Do.
Do.	(336) Mr. Kashinath Ramchandra Pandey.	Do.	P. L.	27	20th May 1909.	Do.
Do.	(337) Diwan Bahadur Kasturchand Daga of Kamptee.	Do.	P. L.	615	12th July 1909.	Do.
Do.	(338) Messrs. Lal Behari Naraindass and Ramcharan Shunkar Lal.	Do.	P. L.	197	10th August 1909.	Do.
Do.	(339) Dewan Bahadur Kasturchand Daga.	Do.	M. L.	320	11th August 1909.	30 years.
Do.	(340) Messrs. Lal Behari Naraindass.	Do.	M. L.	35	26th July 1909.	5 years.
Do.	(341) Mr. D. Laxminarayan.	Do.	M. L.	21	29th July 1909.	30 years.
Do.	(342) Mr. Gowardhandas	Do.	P. L.	55	5th August 1909.	1 year.

E. L. denotes Exploring License ; P. L., Prospecting License ; and M. L., Mining Lease

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantor.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Bhandara .	(343) Seth Gowardhandas	Manganese .	P. L.	100	2nd August 1900.	1 year.
Do. .	(344) Messrs. Kassambhoy, Gopaldass and Co.	Do. .	P. L.	81	Do. .	Do.
Do. .	(345) Do. do. .	Do. .	P. L.	322	27th July 1900.	Do.
Do. .	(346) Messrs. Shanji Madhoji.	Do. .	P. L.	100	16th September 1900.	Do.
Do. .	(347) Messrs. Schroder, Smidt & Co.	Do. .	P. L.	50	6th August 1900.	Do.
Do. .	(348) Do. do. .	Do. .	P. L.	146	7th August 1900.	Do.
Do. .	(349) Do. do. .	Do. .	P. L.	35	Do. .	Do.
Do. .	(350) Dewan Bahadur Kasturchand Daga.	Do. .	P. L.	39	10th August 1900.	Do.
Do. .	(351) Messrs. Kassambhoy, Gopaldass and Mahadeo Seth.	Do. .	P. L.	151	1st September 1900.	Do.
Do. .	(352) Do. do. .	Do. .	P. L.	494	2nd August 1900.	Do.
Do. .	(353) Do. do. .	Do. .	P. L.	263	27th July 1900.	Do.
Do. .	(354) Do. do. .	Do. .	P. L.	57	6th August 1900.	Do.
Do. .	(355) Central India Mining Co. Ltd.	Do. .	M. L.	2	20th September 1900.	30 years.
Do. .	(356) Messrs. Bramhadatt and Baijnath.	Do. .	P. L.	337	22nd August 1900.	1 year.
Do. .	(357) Seth Beharilal. Pokarnal	Do. .	P. L.	31	23rd August 1900.	Do.
Do. .	(358) Mr. T. Cooverji Bhoja.	Do. .	P. L.	2,000	8th December 1900.	Do.
Do. .	(359) Messrs. Rampershad and Laxminarayau.	Do. .	P. L.	446	22nd December 1900.	Do.
Do. .	(360) Messrs. Radhakisan and Brothers.	Do. .	P. L.	7	21st October 1900.	Do.
Do. .	(361) Mr. D. Gangadhar Rao.	Do. .	P. L.	52	24th November 1900.	Do.
Do. .	(362) Rai Sahib Mathura Prasad and Motilal.	Do. .	M. L.	4	30th September 1900.	30 years.
Do. .	(363) Mr. P. Balkrishna Naidu.	Do. .	M. L.	92	2nd November 1900.	Do.
Do. .	(364) Mr. E. Nagannah Naidu.	Do. .	M. L.	10	11th November 1900.	5 years.

E. L. denotes Exploring License : P. L., Prospecting License : and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Bhandara	(365) Dewan Bahadur Kasturchand Daga.	Manganese.	P. L.	88	2nd August 1900.	1 year.
Do.	(366) Seth Jagannath of Tumsar.	Do.	M. L.	41	26th November 1909.	30 years.
Do.	(367) Mr. Rambilas Murlidhar.	Do.	P. L.	29	11th October 1909.	1 year.
Do.	(368) Messrs. Sitharam Nathu and Govind Sitharam of Lakhni.	Do.	P. L.	32	21st October 1900.	Do.
Do.	(369) Mr. E. C. Dungore	Do.	P. L.	62	22nd December 1900.	Do.
Do.	(370) Mr. Rambilas Murlidhar.	Do.	P. L.	185	17th December 1909.	Do.
Do.	(371) Messrs. Sitharam Nathu and Govind Sitharam.	Do.	P. L.	68	Do.	Do.
Do.	(372) Nagpur Manganese Mining Syndicate, Ltd.	Do.	P. L.	218	16th November 1909.	Do.
Chanda	(373) Mr. Byramji Pestonji.	All minerals	E. L.	Entire village	15th March 1900.	Do.
Do.	(374) Do. do.	Do.	E. L.	Do.	Do.	Do.
Do.	(375) Messrs. Umarali Brothers.	Do.	E. L.	5,345	5th July 1909.	Do.
Do.	(376) Messrs. H. Verua and Kanhayalal.	Coal	P. L.	1,363	2nd December 1909.	Do.
Do.	(377) Do. do.	Do.	P. L.	2,976	Do.	Do.
Do.	(378) Do. do.	All minerals	E. L.	6,663	29th November 1900.	Do.
Do.	(379) Do. do.	Do.	E. L.	8,758	Do.	Do.
Chhindwara	(380) Indian Manganese Company, Ltd.	Manganese	M. L.	24	6th January 1909.	30 years.
Do.	(381) Messrs. Macheth Brothers & Co.	Coal	P. L.	992	22nd January 1909.	1 year.
Do.	(382) R. S. Mathura Parsad and Motilal.	Manganese	M. L.	17	12th March 1909.	30 years.
Do.	(383) Mr. W. Stalkartt	Do.	P. L.	324	27th April 1909.	1 year.
Do.	(384) Messrs. Abdur Rahim Khan and Khimji Cooverji.	Coal	P. L.	4,889	14th June 1909.	Do.
Do.	(385) Mr. D. N. Mitra	Manganese	P. L.	105	22nd May 1909.	Do.
Do.	(386) Mr. J. C. Stalkartt	Do.	P. L.	90	9th June 1909.	Do.

CENTRAL PROVINCES--*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Chhindwara .	(387) Rai Saheb Mathura Prasad Motilal and Co.	All minerals .	E. L. .	5,506	12th June 1909.	1 year.
Do. .	(388) Indian Manganese Co., Ltd.	Manganese .	P. L. .	58	21st July 1909.	Do.
Do. .	(389) Messrs. P. S. Kotwal and S. R. Naidu.	Do. .	P. L. .	96	4th November 1909.	Do.
Do. .	(390) Messrs. Baiya Lal and Narur Patel.	Do. .	P. L. .	101	21st October 1909.	Do.
Do. .	(391) Mr. A. C. Blechyn-den of Jabulpore.	Do. .	P. L. .	20	15th December 1909.	Do.
Do. .	(392) Do. do. .	Do. .	P. L. .	26	Do. .	Do.
Do. .	(393) Mr. Govind Rao Baji Rao Desimukh of Keled.	Do. .	P. L. .	79	14th December 1909.	Do.
Do. .	(394) The Indian Manganese Co.	All minerals .	E. L. .	1,557	11th November 1909.	Do.
Drug .	(395) Lala Indrasbahi, Zamindar, Ambagarh Chowki.	Lead and quick-silver.	P. L. .	167	18th May 1909.	Do.
Jabulpore .	(396) Messrs. P. S. Kotwal and S. R. Naidu.	Manganese .	P. L. .	438	1st March 1909.	Do.
Do. .	(397) Do. do. .	Do. .	P. L. .	102	22nd March 1909.	Do.
Do. .	(398) Do. do. .	Do. .	P. L. .	49	15th June 1909.	Do.
Do. .	(399) The Bombay Prospecting and Mining Syndicate.	Soapstone, steatite, and talc.	P. L. .	647	21st April 1909.	Do.
Do. .	(400) Mr. D. W. A. MacDonald of Murwara.	All minerals .	E. L. .	40	24th April 1909.	Do.
Do. .	(401) Do. do. .	Do. .	E. L. .	567	Do. .	Do.
Do. .	(402) Messrs. P. S. Kotwal and S. R. Naidu.	Manganese .	P. L. .	46	5th July 1909.	Do.
Do. .	(403) Do. do. .	Do. .	P. L. .	242	Do. .	Do.
Do. .	(404) Bombay Prospecting and Mining Syndicate.	Bauxite .	P. L. .	375	26th July 1909.	Do.
Do. .	(405) Mr. M. Gupta, Barrister-at-Law, Hoshangabad.	All minerals .	E. L. .	684	23rd July 1909.	Do.
Do. .	(406) Mr. R. K. Kanga .	Manganese and iron.	P. L. .	371	30th September 1909.	Do.
Do. .	(407) Do. do. .	Do. .	P. L. .	202	20th August 1909.	Do.

E. L. denotes Exploring License ; P. L. Prospecting License ; and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Jubbulpore	(408) Messrs. C. MacDonald & Co.	All minerals	E. L.	633	15th July 1909.	1 year.
Do.	(409) Do. do.	Iron	P. L.	633	31st August 1909.	Do.
Do.	(410) Mr. M. Gupta, Barrister-at-Law, Hosangabad.	Soapstone, steatite and talc.	P. L.	216	20th September 1909.	Do.
Do.	(411) Mr. P. C. Dutt, Barrister-at-Law, Jubbulpore.	All minerals	E. L.	2,586	30th July 1909.	Do.
Do.	(412) Bombay Prospecting and Mining Syndicate.	Do.	E. L.	1,697	23rd July 1909.	Do.
Do.	(413) Messrs. Burn and Co. and P. C. Dutt.	Gold, silver, copper and lead.	M. L.	49	5th October 1909.	30 years.
Do.	(414) Messrs. H. F. Cook & Sons, Murwara.	Bauxite	P. L.	288	16th December 1909.	1 year.
Do.	(415) Mr. C. Vehr Ayah.	Manganese	P. L.	207	29th October 1909.	Do.
Do.	(416) Seth Timorasji Cowasji.	Coal	P. L.	86	8th November 1909.	Do.
Nagpur	(417) Messrs. B. B. B. Fouzdar Brothers.	Manganese and mica.	P. L.	439	13th March 1909.	Do.
Do.	(418) Messrs. Jessop & Co.	Manganese	M. L.	90	12th March 1909.	30 years.
Do.	(419) Mr. Venkat Rao Naik.	Do.	P. L.	18	2nd March 1909.	1 year.
Do.	(420) Lala B. Sitaran, Kamptee.	Do.	P. L.	279	16th January 1909.	Do.
Do.	(421) Messrs. B. B. B. Fouzdar and Brothers.	Manganese and coal.	P. L.	26	13th March 1909.	Do.
Do.	(422) Hon'ble Mr. G. M. Chitnavis of Nagpur.	Manganese	P. L.	278	13th February 1909.	Do.
Do.	(423) Mr. S. O. Holmes	Manganese, iron, copper, tin, bismuth, wolfram and molybdenum.	P. L.	65	7th January 1909.	Do.
Do.	(424) Mr. Pyramji Postonji.	Manganese	P. L.	301	20th March 1909.	Do.
Do.	(425) Hon'ble Mr. G. M. Chitnavis.	Do.	P. L.	50	29th March 1909.	Do.
Do.	(426) Central Provinces Prospecting Syndicate, Ltd.	Do.	M. L.	37	22nd January 1909.	30 years.
Do.	(427) Mr. S. O. Holmes	Manganese, iron, tin, copper, wolfram and bismuth.	P. L.	513	7th January 1909.	1 year.

E. L. denotes Exploring License ; P. L., Prospecting License ; and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur	(428) Mr. S. O. Holmes.	Manganese, iron, tin, copper, wolfram and bismuth.	P. L.	287	7th January 1909.	1 year.
Do.	(429) Messrs. P. S. Kotwal and S. R. Naidu.	Manganese.	P. L.	165	31st March 1909.	Do.
Do.	(430) Mr. Byramji Pestonji.	Do.	P. L.	599	Do.	Do.
Do.	(431) Mr. Darashah Mancherji of Kamptee.	Do.	P. L.	102	8th February 1909.	Do.
Do.	(432) Mr. Venkat Rao Nalk.	Do.	P. L.	1,084	2nd March 1909.	Do.
Do.	(433) Messrs. Martin & Co.	Manganese, iron, tin, bismuth and molybdenum.	P. L.	363	21st January 1909.	Do.
Do.	(434) Messrs. P. S. Kotwal and S. R. Naidu.	Manganese.	P. L.	210	31st January 1909.	Do.
Do.	(435) Mr. Herchandial Sitarau.	Do.	P. L.	85	7th January 1909.	Do.
Do.	(436) Mr. Byramji Pestonji.	Do.	P. L.	70	23rd March 1909.	Do.
Do.	(437) Messrs. Ramprasad and Laxminarayana.	Do.	P. L.	125	7th January 1909.	Do.
Do.	(438) Indian Manganese Co., Ltd.	Do.	P. L.	49	21st January 1909.	Do.
Do.	(439) Do. do.	Do.	P. L.	18	Do.	Do.
Do.	(440) Mr. G. M. Prichard	All minerals.	E. L.	853	27th January 1909.	Do.
Do.	(441) Do. do.	Do.	E. L.	70	Do.	Do.
Do.	(442) Mr. G. M. Chitnavis	Manganese.	P. L.	306	29th March 1909.	Do.
Do.	(443) Central India Mining Co., Ltd., Kamptee.	Do.	P. L.	235	8th February 1909.	Do.
Do.	(444) Do. do.	Do.	P. L.	348	Do.	Do.
Do.	(445) Messrs. Martin & Co.	All minerals.	E. L.	729	21st January 1909.	Do.
Do.	(446) Messrs. P. S. Kotwal and S. R. Naidu.	Manganese, iron, bismuth, wolfram and molybdenum.	P. L.	153	27th January 1909.	Do.
Do.	(447) Mr. Byramji Pestonji.	All minerals.	E. L.	213	13th February 1909.	Do.
Do.	(448) Do. do.	Do.	E. L.	2,758	Do.	Do.

E. L. denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur	(440) Mr. S. O. Holmes	Manganese, wolfram, iron, bismuth, tin, copper and molybdenum.	P. L.	299	23rd March 1909.	1 year.
Do.	(450) Mr. P. Balkrishna Naidu.	Manganese	P. L.	102	2nd March 1909.	Do.
Do.	(451) Messrs. P. S. Kotwal and S. R. Naidu.	Do.	P. L.	49	13th May 1909.	Do.
Do.	(452) Nagpur Manganese Mining Syndicate.	Do.	P. L.	46	4th March 1909.	Do.
Do.	(453) Nagpur Manganese Mining Syndicate, Ltd.	Do.	P. L.	135	Do.	Do.
Do.	(454) Mr. E. C. Dungore	Do.	P. L.	13	27th January 1909.	Do.
Do.	(455) Nagpur Manganese Mining Syndicate, Ltd.	Do.	P. L.	85	16th February 1909.	Do.
Do.	(456) Mr. Byramji Pestonji.	Galena	P. L.	265	29th March 1909.	Do.
Do.	(457) Nagpur Manganese Mining Syndicate, Ltd.	Manganese	P. L.	45	25th March 1909.	Do.
Do.	(458) Do. do.	All minerals	E. L.	35	21st January 1909.	Do.
Do.	(459) Do. do.	Do.	E. L.	115	Do.	Do.
Do.	(460) Do. do.	Do.	E. L.	247	Do.	Do.
Do.	(461) Do. do.	Do.	E. L.	116	Do.	Do.
Do.	(462) Do. do.	Do.	E. L.	118	13th March 1909.	Do.
Do.	(463) Do. do.	Do.	E. L.	0-29	8th February 1909.	Do.
Do.	(464) Do. do.	Do.	E. L.	101	21st January 1909.	Do.
Do.	(465) Do. do.	Do.	E. L.	49	5th February 1909.	Do.
Do.	(466) Do. do.	Do.	E. L.	55	8th February 1909.	Do.
Do.	(467) Mr. Byramji Pestonji.	Do.	E. L.	239	2nd March 1909.	Do.
Do.	(468) Nagpur Manganese Mining Syndicate, Ltd.	Do.	E. L.	148	8th February 1909.	Do.
Do.	(469) Mr. Byramji Pestonji.	Do.	E. L.	1,407	29th March 1909.	Do.
Do.	(470) Nagpur Manganese Mining Syndicate, Ltd.	Do.	E. L.	404	13th March 1909.	Do.

E. L. denotes Exploring License ; P. L., Prospecting License ; and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur	(471) Nagpur Manganese Mining Syndicate, Ltd.	All minerals	E. L.	45	25th February 1909.	1 year.
Do.	(472) Do. do.	Do.	E. L.	106	13th March 1909.	Do.
Do.	(473) Do. do.	Do.	E. L.	41	Do.	Do.
Do.	(474) Do. do.	Do.	E. L.	82	Do.	Do.
Do.	(475) Mr. Byramji Pestonji.	Do.	E. L.	250	20th March 1909.	Do.
Do.	(476) Do. do.	Do.	E. L.	339	2nd March 1909.	Do.
Do.	(477) Do. do.	Do.	E. L.	375	29th March 1909.	Do.
Do.	(478) Messrs. Umarali Brothers.	Lead.	P. L.	52	4th March 1909.	Do.
Do.	(479) Nagpur Manganese Mining Syndicate, Ltd.	All minerals	E. L.	58	25th March 1909.	Do.
Do.	(480) The Central Provinces Prospecting Syndicate, Ltd.	Manganese.	M. L.	5	12th April 1909.	30 years.
Do.	(481) Mr. D. Laxminarayan.	Do.	P. L.	184	28th April 1909.	1 year.
Do.	(482) The Central India Mining Co., Ltd.	Do.	M. L.	8	19th April 1909.	30 years.
Do.	(483) Messrs. Kassambhoy Ramjee & Co.	Do.	P. L.	8	11th May 1909	1 year.
Do.	(484) Lala Mohanlal Kalar.	Do.	P. L.	375	22nd June 1909.	Do.
Do.	(485) Messrs. Kassambhoy Ramjee & Co.	Do.	P. L.	125	11th May 1909	Do.
Do.	(486) Do. do.	Do.	P. L.	55	Do.	Do.
Do.	(487) Mr. M. B. Dadabhoy	Do.	P. L.	85	Do.	Do.
Do.	(488) Messrs. P. S. Kotwal and S. R. Naidu.	Do.	P. L.	924	22nd May 1909	Do.
Do.	(489) Messrs. Kassambhoy Ramjee & Co.	Do.	P. L.	50	16th June 1909.	Do.
Do.	(490) Messrs. Ramprasad and Laxminarayan.	Do.	P. L.	53	28th April 1909.	Do.
Do.	(491) The Central Provinces Prospecting Syndicate, Ltd.	Do.	M. L.	31	3rd April 1909.	30 years.
Do.	(492) Messrs. P. S. Kotwal and S. R. Naidu.	Do.	P. L.	210	31st March 1909.	1 year.
Do.	(493) Mir Aslam Khan of Ramtek.	Do.	P. L.	187	18th May 1909	Do.

E. L. denotes Exploring License ; P. L., Prospecting License ; and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur	(494) Mr. Byramji Pestonji.	All minerals	E. L.	1,577	22nd June 1909.	1 year.
Do.	(495) Do. do.	Manganese and copper.	P. L.	46	11th May 1909	Do.
Do.	(496) Do. do.	Do.	P. L.	110	Do.	Do.
Do.	(497) Mr. T. B. Kantharia.	Manganese	P. L.	92	28th April 1909.	Do.
Do.	(498) Mr. Hanmant Rao Yelaji Rao Mohitey.	Do.	P. L.	102	11th May 1909	Do.
Do.	(499) Mr. T. B. Kantharia.	Do.	P. L.	90	28th April 1909.	Do.
Do.	(500) Mr. M. B. Dadabhoi	Do.	P. L.	11	11th May 1909	Do.
Do.	(501) Mr. T. B. Kantharia.	Do.	P. L.	148	28th April 1909.	Do.
Do.	(502) The Central Provinces Prospecting Syndicate, Ltd.	Do.	M. L.	46	1st May 1909	30 years.
Do.	(503) Mr. Herchand Lal Sitaram.	Do.	P. L.	205	17th April 1909.	1 year.
Do.	(504) Mr. Byramji Pestonji.	Do.	P. L.	76	11th May 1909	Do.
Do.	(505) Mr. Herchand Lal Sitaram.	Do.	P. L.	248	16th June 1909.	Do.
Do.	(506) Mr. Byramji Pestonji.	Do.	P. L.	27	22nd June 1909.	Do.
Do.	(507) Mr. T. B. Kantharia.	Do.	P. L.	100	28th April 1909.	Do.
Do.	(508) Do. do.	Do.	P. L.	100	Do.	Do.
Do.	(509) Mr. E. C. Dungore.	Do.	P. L.	212	22nd June 1909.	Do.
Do.	(510) Nagpur Manganese Mining Syndicate, Ltd.	Do.	P. L.	52	22nd May 1909.	Do.
Do.	(511) Do. do.	Do.	P. L.	58	Do.	Do.
Do.	(512) Do. do.	Do.	P. L.	35	13th April 1909.	Do.
Do.	(513) Do. do.	Do.	P. L.	101	22nd June 1909.	Do.
Do.	(514) Lala Balibhadra and Mohaulal.	Do.	P. L.	166	28th April 1909.	Do.
Do.	(515) Nagpur Manganese Mining Syndicate, Ltd.	Do.	P. L.	42	22nd May 1909.	Do.
Do.	(516) Do. do.	Do.	P. L.	89	Do.	Do.

E. L. denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

CENTRAL PROVINCES—contd.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur	(517) Messrs. Umarali Brothers.	All minerals	E. L.	396	17th April 1909.	1 year.
Do.	(518) Do. do.	Do.	E. L.	1,873	Do.	Do.
Do.	(519) Nagpur Manganese Mining Syndicate, Ltd.	Manganese	P. L.	41	22nd May 1909.	Do.
Do.	(520) Mr. E. G. Beckett.	All minerals	E. L.	610	16th June 1909.	Do.
Do.	(521) Do. do.	Do.	E. L.	43	Do.	Do.
Do.	(522) Do. do.	Do.	E. L.	819	Do.	Do.
Do.	(523) Do. do.	Do.	E. L.	1,192	Do.	Do.
Do.	(524) Nagpur Manganese Mining Syndicate, Ltd.	Do.	E. L.	18	17th April 1909.	Do.
Do.	(525) Mr. Byramji Pestonji.	Do.	E. L.	1,211	22nd June 1909.	Do.
Do.	(526) Messrs. R. K. Chulani & Sons.	Do.	E. L.	14	16th May 1909	Do.
Do.	(527) Messrs. Umarali Brothers.	Do.	E. L.	1,221	Do.	Do.
Do.	(528) Nagpur Manganese Mining Syndicate, Ltd.	Do.	E. L.	62	17th April 1909.	Do.
Do.	(529) Do. do.	Do.	E. L.	37	Do.	Do.
Do.	(530) Mr. Dhawakahnai Gunpatilal.	Do.	E. L.	83	11th May 1909	Do.
Do.	(531) Do. do.	Do.	E. L.	31	25th May 1909	Do.
Do.	(532) Nagpur Manganese Mining Syndicate, Ltd.	Do.	E. L.	1,225	12th June 1909.	Do.
Do.	(533) Do. do.	Do.	E. L.	149	Do.	Do.
Do.	(534) Do. do.	Do.	E. L.	575	22nd June 1909.	Do.
Do.	(535) Messrs. Kassambhoy Ramjee & Co.	Do.	E. L.	776	29th June 1909.	Do.
Do.	(536) Bansilal Abeerchand Mining Syndicate (Mr. T. Cooverji Bhoja of Calcutta).	Manganese	M. L.	200	3rd September 1909.	30 years.
Do.	(537) Mr. Madhulal Doogar of Calcutta.	Do.	P. L.	195	3rd July 1909.	1 year.
Do.	(538) Messrs. Jessop and Company of Calcutta.	Do.	P. L.	1,877	10th July 1909.	Do.
Do.	(539) The Central India Mining Co., Ltd.	Do.	M. L.	63	24th June 1909.	30 years.
Do.	(540) The Central Provinces Prospecting Syndicate, Ltd.	Do.	M. L.	42	22nd June 1909.	Do.

E. L. denotes Exploring License : P. L., Prospecting License : and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur	(541) Satak Mangancse Co.	Manganese .	M. L. .	64	16th August 1909.	30 years.
Do.	(542) Hon'ble Mr. M. B. Dadebhoy.	Do. . .	P. L. .	765	20th August 1909.	1 year.
Do.	(543) Do. do. .	Do. . .	P. L. .	128	Do. .	Do.
Do.	(544) Messrs. Kassambhoy Ramjee & Co.	Do. . .	P. L. .	28	29th September 1909.	Do.
Do.	(545) The Indian Mangane Mining Company, Ltd.	Do. . .	P. L. .	72	28th August 1909.	Do.
Do.	(546) Mr. D. Laxminarayan of Kamptee.	Do. . .	M. L. .	76	21st June 1909.	30 years.
Do.	(547) Mr. Shamji Madhoji	Copper . .	P. L. .	53	27th September 1909.	1 year.
Do.	(548) Mr. Nowroji Pethonji of Bombay.	Manganese, galena, molybdenum and lead.	P. L. .	1,316	Do. .	Do.
Do.	(549) Mr. Byramji Pestonji of Raipur.	Manganese, mica, hauxite, galena and asbestos.	P. L. .	53	20th August 1909.	Do.
Do.	(550) Mr. Shamji Madhoji	Manganese .	P. L. .	238	27th September 1909.	Do.
Do.	(551) Mr. D. Gungadhar Rao.	Do. . .	P. L. .	10	10th July 1909.	Do.
Do.	(552) Mr. Byramji Pestonji.	All minerals .	E. L. .	3,825	20th August 1909.	Do.
Do.	(553) Mr. G. M. Prichard	Manganese .	P. L. .	46	10th August 1909.	Do.
Do.	(554) Messrs. Ramprasad and Laxminarayan.	Manganese, wolfram, tin and copper.	P. L. .	20	27th September 1909.	Do.
Do.	(555) The Central India Mining Co., Ltd.	Manganese .	M. L. .	99	24th June 1909.	30 years.
Do.	(556) Mr. T. B. Kantharia.	Do. . .	P. L. .	150	6th August 1909.	1 year.
Do.	(557) Mr. P. Falkrishna Naidu.	Do. . .	P. L. .	100	Do. .	Do.
Do.	(558) Mr. Vinayak Rao Vaidya.	Do. . .	P. L. .	139	20th August 1909.	Do.
Do.	(559) Mr. Byramji Pestonji.	All minerals .	E. L. .	637	3rd July 1909	Do.
Do.	(560) Messrs. Schroder, Smidt & Co.	Manganese .	P. L. .	338	27th July 1909	Do.
Do.	(561) Messrs. R. K. Chulany & Son.	Mica . . .	P. L. .	107	17th August 1909.	Do.

E. L. denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur	(562) The Central India Mining Co., Ltd.	Wolfram	P. L.	231	30th September 1909.	1 year.
Do.	(563) Nagpur Manganese Mining Syndicate, Ltd.	Manganese	P. L.	58	27th July 1909.	Do.
Do.	(564) Mr. Dhawak Malji Gunpat Lal.	Do.	P. L.	83	6th March 1909.	Do.
Do.	(565) Nagpur Manganese Mining Syndicate, Ltd.	Do.	P. L.	18	15th July 1909	Do.
Do.	(566) Messrs. Rafanchand Kesrichand Chullany & Sons.	Do.	P. L.	58	28th August 1909.	Do.
Do.	(567) Mr. A. Hanmant Rao.	Do.	P. L.	30	20th August 1909.	Do.
Do.	(568) Mr. P. Balkrishna Naidu.	Do.	P. L.	45	6th August 1909.	Do.
Do.	(569) Messrs. Shawakshah Jamsetji Dubash and Bapuji Jamsetji Dubash.	All minerals	E. L.	45	15th July 1909	Do.
Do.	(570) Nagpur Manganese Mining Syndicate, Ltd.	Do.	E. L.	109	Do.	Do.
Do.	(571) Mr. Byranji Pestonji.	Do.	E. L.	672	20th August 1909.	Do.
Do.	(572) Messrs. Shawakshah Jamsetji Dubash and Bapuji Jamsetji Dubash.	Do.	E. L.	97	4th August 1909.	Do.
Do.	(573) Nagpur Manganese Mining Syndicate, Ltd.	Do.	E. L.	97	Do.	Do.
Do.	(574) Messrs. P. S. Kotwal and S. R. Naidu.	Manganese	P. L.	112	17th November 1909.	Do.
Do.	(575) Messrs. Radhakisan Brothers.	Do.	P. L.	28	9th October 1909.	Do.
Do.	(576) Messrs. Schroder, Smidt & Co.	Do.	P. L.	111	Do.	Do.
Do.	(577) Messrs. P. S. Kotwal and S. R. Naidu.	Do.	P. L.	108	24th November 1909.	Do.
Do.	(578) Messrs. Raniprasad and Laxminarayan.	All minerals	E. L.	320	22nd December 1909.	Do.
Do.	(579) Seth Dawakmalji Ganpatlal.	Manganese	P. L.	31	9th October 1909.	Do.
Do.	(580) Nagpur Manganese Mining Syndicate, Ltd.	Do.	P. L.	140	30th October 1909.	Do.
Do.	(581) Do. do.	Do.	P. L.	581	10th December 1909.	Do.
Do.	(582) Lala Bansilal Katar	Do.	P. L.	74	Do.	Do.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur	(583) Lala Bansilal Kalar	Manganese.	P. L.	29	10th December 1909.	1 year.
Do.	(584) Nagpur Manganese Mining Co., Ltd.	Do.	P. L.	31	17th November 1909.	Do.
Do.	(585) Mr. P. Balkrishna Naidu.	Do.	P. L.	54	10th December 1909.	Do.
Do.	(586) Messrs. Schroder, Smidt & Co.	Do.	P. L.	94	17th November 1909.	Do.
Do.	(587) Nagpur Manganese Mining Syndicate, Ltd.	All minerals	E. L.	6	27th July 1909.	Do.
Do.	(588) Messrs. Schroder, Smidt & Co.	Manganese	P. L.	68	10th December 1909.	Do.
Do.	(589) Nagpur Manganese Mining Syndicate, Ltd.	Do.	P. L.	190	Do.	Do.
Do.	(590) Do. do.	All minerals	E. L.	527	30th October 1909.	Do.
Do.	(591) Do. do.	Do.	E. L.	190	9th October 1909.	Do.
Do.	(592) Do. do.	Do.	E. L.	168	7th November 1909.	Do.
Do.	(593) Seth Balkrishna (on behalf of Rupchand Gaibitram).	Do.	E. L.	848	Do.	Do.
Do.	(594) Nagpur Manganese Mining Syndicate, Ltd.	Do.	E. L.	195	10th December 1909.	Do.
Do.	(595) Do. do.	Do.	E. L.	72	17th November 1909.	Do.
Do.	(596) Do. do.	Do.	E. L.	9	Do.	Do.
Do.	(597) Do. do.	Do.	E. L.	92	Do.	Do.
Do.	(598) Do. do.	Do.	E. L.	128	22nd December 1909.	Do.
Do.	(599) Mr. Darasha Muncherji Dungaji.	Do.	E. L.	184	24th November 1909.	Do.
Do.	(600) Nagpur Manganese Mining Syndicate, Ltd.	Do.	E. L.	143	22nd December 1909.	Do.
Raipur	(601) Mr. Batu Krishna Gupta of Bilaspur.	Graphite	P. L.	1,355	17th February 1909.	Do.
Do.	(602) Mr. R. K. Kanga	Do.	P. L.	124	13th March 1909.	Do.
Do.	(603) Do. do.	All minerals	E. L.	2,381	16th June 1909.	Do.
Do.	(604) Messrs. Kassambhoy Ramjee & Co.	Lead	P. L.	114	5th June 1909	Do.
Do.	(605) Do. do.	All minerals	E. L.	114	3rd May 1909	Do.

E. L. denotes Exploring License ; P. L., Prospecting License ; and M. L., Mining Lease.

CENTRAL PROVINCES—*concl.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Raipur . .	(606) Messrs. Byramji Pestonji & Co.	All minerals .	E. L. .	2,466	10th June 1900.	1 year.
Do. . .	(607) Do. do. .	Do. .	E. L. .	707	Do. .	Do.
Do. . .	(608) Messrs. Kassambhoy Ramjee & Co.	Do. .	E. L. .	925	5th June 1900	Do.
Do. . .	(609) Mr. R. K. Kanga .	Manganese, coal, iron, graphite and lead.	P. L. .	2,381	25th September 1900.	Do.
Saugor . .	(610) Gantpat Rao Shrikande, Gopal Rao and Ramkrishna Rao Shrikande, retired E. A. C., and pleaders at Saugor.	Gold, silver, copper, coal, iron and mineral oil.	P. L. .	368	10th March 1900.	Do.
Seoni . .	(611) Messrs. Schroder, Smidt & Co., Calcutta, per L. De Souza, Agent and Attorney, Nagpur.	Manganese .	P. L. .	46	8th September 1900.	Do.
Do. . .	(612) Messrs. A. C. Blechynden of Jubbulpore.	All minerals .	E. L. .	Three whole villages of Kali r u t h, K a r h a i y a and Dun-garia.	16th August 1900.	Do.
Do. . .	(613) Mr. Khimji Cooverji	Iron . . .	P. L. .	2,292	18th December 1900.	Do.
Wardha . .	(614) Rao Bahadur Rajaram Pant Dixit.	Coal . . .	P. L. .	2,715	27th April 1900.	Do.

EASTERN BENGAL AND ASSAM.

Chittagong .	(615) Messrs. Turner, Morrison & Co., Calcutta.	Coal, oil, iron, etc.	P. L. (renewal)	2,675	10th July 1900.	1 year.
Lakhimpur .	(616) The Assam Railways and Trading Co., Ltd., of Dibrugarh.	Coal, iron, etc. .	P. L. .	22,400	15th January 1900.	Do.
Do. . .	(617) Babu Sew Narain Beria of Dibrugarh.	Coal . . .	P. L. (renewal)	9,516.80	1st April 1900	Do.

MADRAS.

Bellary . .	(618) South Indian Mining Syndicate.	Manganese .	M. L. .	1,591.29	18th May 1900	30 years.
Do. . .	(619) S. Craushaw .	All minerals .	E. L. .	The bed of the Tungabhadra running through the district.	9th August 1900.	1 year.

E. L. denotes Exploring License ; P. L., Prospecting License ; and M. L., Mining Lease.

MADRAS—contd.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term
Coimbatore	(620) T. R. Venkataramana Aiyar.	Mica and other minerals.	E. L.	All Government waste lands, including reserved forests.	26th April 1909.	1 year.
Do.	(621) C. V. Narasian	Corundum, asbestos, gypsum, manganese, crystals and precious stones.	P. L.	5,445'90	Do.	Do
Do.	(622) Do. do.	Mica	P. L.	211'92	Do.	Do.
Cuddapah	(623) Beardsell & Co.	Not given	E. L.	Not given	February 1900	Do.
Do.	(624) L. E. Karwan	Galeua	P. L.	576'88	25th July 1909.	Do.
Do.	(625) W. R. C. Beaden	Lead	P. L.	640	3rd September 1900.	Do.
Do.	(626) T. R. Tawker & Sons.	Tin, lead, copper and iron ore.	P. L.	30'60	24th December 1900.	4 months.
Do.	(627) P. Venkatappa	Lead	P. L.	83'00	10th December 1900.	8 months.
Do.	(628) Bavadin & Co.	Gold	P. L.	135'77	4th November 1900.	1 year.
Kistna	(629) South Indian Coal Mining Co.	Not reported	E. L.	All Government villages.	23rd September 1900.	Do.
Kurnool	(630) A. Ghose	Diamond	P. L.	2,267	26th February 1900.	Do.
Do.	(631) Beardsell & Co.	All minerals	E. L.	All Government waste lands, including reserved forests.	18th January 1900.	Do.
Do.	(632) T. C. Swami & Co.	Iron ore or any other metal or precious stones.	E. L.	Not given	5th March 1900.	Do.
Do.	(633) Leon Tardival (by Agent).	Diamonds, lead, zinc ores and barytes.	P. L.	848'5	9th November 1900.	Do.
Do.	(634) W. A. Beardsell & Co.	Manganese	P. L.	600	4th December 1900.	Do.
Do.	(635) Shaik Meera Sahib & Co.	All minerals	E. L.	All unoccupied lands.	19th October 1900.	Do.
Do.	(636) A. Ghose	Do.	P. L.	2'18	9th November 1900.	Do.
Do.	(637) Abdul Karim Sahib.	Barytes	P. L.	374	15th December 1900.	Do.
Do.	(638) Beardsell & Co.	Do.	P. L.	583	2nd December 1900.	Do.
Nellore	(639) P. Venkatarama Nayudu.	Mica	M. L. (patta land)	15'88	4th February 1900.	20 years.

E. L. denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

MADRAS—contd.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement	Term.
Nellore . .	(640) D. Venkata Rao	Mica . . .	M. L. .	28'82	1st November 1908.	20 years.
Do. . .	(641) L. Chenga Reddi .	Do. . . .	M. L. .	18'80	12th February 1909.	30 years.
Do. . .	(642) K. Krishnaswami Mudaliyar.	Do. . . .	P. L. .	12'02	25th February 1909.	6 months.
Do. . .	(643) Kali Chetti Penchal Reddi.	Do. . . .	P. L. .	13'13	12th March 1909.	1 year.
Do. . .	(644) K. Krishnaswami Mudaliyar.	Do. . . .	P. L. .	14'00	8th March 1909.	6 months.
Do. . .	(645) Y. Venkatasubbiah and two others.	Do. . . .	M. L. (patta land)	303'01	17th January 1909.	20 years.
Do. . .	(646) B. Chenchu Raniiah	Do. . . .	P. L. .	76'21	14th April 1909.	1 year.
Do. . .	(647) M. Gulam Hussain and P. Venkatasubbiah.	Do. . . .	M. L. (patta land)	2'75	20th June 1909.	20 years.
Do. . .	(648) R. Lakshminaras Reddi.	Do. . . .	M. L. .	6'20	14th April 1909.	30 years.
Do. . .	(649) Muhammad Fasil-uddin Sahib.	Do. . . .	M. L. .	12'30	20th March 1909.	Do.
Do. . .	(650) K. Adinurayana Reddi.	Do. . . .	P. L. .	25'62	2nd May 1909	1 year.
Do. . .	(651) Y. Venkatasubbiah	Do. . . .	M. L. (patta land)	7'6	14th April 1909.	20 years.
Do. . .	(652) Muhammad Asar-uddin Ahmad Sahib.	Do. . . .	P. L. .	15'17	1st May 1909	1 year.
Do. . .	(653) P. Balarama Reddi	Do. . . .	P. L. .	12'00	30th June 1909.	Do.
Do. . .	(654) Muhammad Badsha Sahib.	Do. . . .	P. L. .	13'08	2nd May 1909	Do.
Do. . .	(655) Muhammad Asa-uddin Ahmad Sahib.	Do. . . .	P. L. .	19'72	25th May 1909	Do.
Do. . .	(656) George Ellegan .	Do. . . .	P. L. .	142'88	26th April 1909.	Do.
Do. . .	(657) K. Panchal Reddi	Do. . . .	P. L. .	12'37	20th September 1909.	Do.
Do. . .	(658) Y. Adema . .	Do. . . .	M. L. .	1'28 (patta land)	7th September 1909.	20 years.
Do. . .	(659) Madras Mica Export Co.	Do. . . .	P. L. .	56'66	22nd August 1909.	1 year.
Do. . .	(660) Do. do. .	Do. . . .	P. L. .	79'20	17th July 1909	Do.
Do. . .	(661) Do. do. .	Do. . . .	P. L. .	42'21	Do. .	Do.
Do. . .	(662) P. Venkatarama Nayudu.	Do. . . .	P. L. .	13'25	22nd September 1909.	Do.

E. L. denotes Exploring License ; P. L., Prospecting License ; and M. L., Mining Lease.

MADRAS—*concl'd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nellore . .	(663) G. Illegan . .	Mica . . .	P. L. . .	10'86	25th July 1909	1 year.
Do. . .	(664) Do. do. . .	Do. . . .	P. L. . .	10'45	Do. . .	Do.
Do. . .	(665) Do. do. . .	Do. . . .	P. L. . .	12'32	Do. . .	Do.
Do. . .	(666) Do. do. . .	Do. . . .	P. L. . .	36'57	Do. . .	Do.
Do. . .	(667) Do. do. . .	Do. . . .	P. L. . .	20'75	Do. . .	Do.
Do. . .	(668) Muhammad Asar- uddin Samib.	Do. . . .	E. L. . .	All unoc- cupied lands.	2nd August 1909.	Do.
Do. . .	(669) K. Adinarayan Reddi.	Do. . . .	E. L. . .	Do. . .	29th August 1909.	Do.
Do. . .	(670) B. Balarami Reddi	Do. . . .	M. L. . .	23'35	10th Decem- ber 1909.	30 years.
Do. . .	(671) P. Penchal Reddi .	Do. . . .	M. L. (renewal)	57'62	20th Septem- ber 1909.	27 years.
Do. . .	(672) K. Adinarayana Reddi.	Do. . . .	P. L. . .	23'00	11th. Decem- ber 1909.	1 year.
Do. . .	(673) N. Obula Reddi .	Do. . . .	M. L. . .	26'41	22nd Decem- ber 1909.	30 years.
Do. . .	(674) J. Balarami Reddi.	Do. . . .	M. L. (extension)	47'00	4th Decem- ber 1909.	27 years.
Do. . .	(675) V. Venkata Sub- bayya Nayudu.	Do. . . .	E. L. . .	All unoc- cupied lands.	25th October 1909.	1 year.
Do. . .	(676) G. Subramanyam .	Do. . . .	P. L. . .	11'20	4th October 1909.	Do.
Do. . .	(677) Chamber & Co. . .	Do. . . .	P. L. . .	12'97	30th January 1909.	Do.
Do. . .	(678) A. T. Tiruvengada- swami Mudaliyar.	Corundum and chronite.	P. L. . .	107'04	1st May 1909	Do.
South Canara .	(679) Hajee Ismail Sahib	Coal . . .	E. L. . .	Whole Taluk	30th July 1909	Do.
Tinnevely . .	(680) Madura Co. . . .	All minerals .	E. L. . .	7,277	12th Decem- ber 1909.	Do.
Trichinopoly .	(681) Leon Tardival's Agent, Mr. A. Ghose.	Phosphatic nodules and gypsum.	P. L. . .	4,522'77	29th Septem- ber 1909.	Do.

NORTH-WEST FRONTIER PROVINCE.

Hazara . .	(682) R. S. Rocha Ram & Sons, Contractors, Abbottabad.	Coal . . .	M. L. . .	19'4	4th June 1909	30 years.
Peshawar, Kohat and Bannu.	(683) The Burma Oil Co., Ltd.	Oil . . .	E. L. . .	British districts of Peshawar, Kohat and Bannu.	21st April 1909.	1 year.

E. L., denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

PUNJAB.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Jhelum .	(684) Panjit Bhola Nath	Coal . . .	P. L. .	55	20th July 1900.	1 year.
Do. .	(685) Lala Thakur Das Ramjee Das.	Do. . . .	P. L. .	92.38	3rd October 1900.	Do.
Mianwali .	(686) Lala Brindaban .	Do. . . .	P. L. .	1,250	1st September 1900.	Do.
Do. .	(687) Do. do. .	Do. . . .	Renewal of P. L. .	1,548	29th September 1900.	Do.
Shahpur .	(688) Arjan Singh of Kapurthala.	Do. . . .	P. L. .	106.19	30th June 1900.	Do.
Do. .	(689) Do. do. .	Do. . . .	P. L. .	29.66	Do. .	Do.
Do. .	(690) Pir Chun Pir .	Do. . . .	Renewal of P. L. .	624.3125	3rd January 1900.	Do.

UNITED PROVINCES.

Jhansi .	(691) Messrs. Dina Nath and Baray Lal Shrivastava.	Copper, lead, silver, mica and other minerals.	P. L. .	138.52	25th January 1909.	1 year.
Do. .	(692) Do. do. .	Do. . . .	P. L. .	1,407.38	16th October 1909.	Do.
Do. .	(693) Do. do. .	Do. . . .	P. L. .	548	Do. .	Do.

SUMMARY.

PROVINCES.	Prospecting Licenses.	Exploring Licenses.	Mining Leases.	Total of each Province.
Baluchistan	4	..	15	19
Bengal	11	..	1	12
Bombay	10	1	3	17
Burma	73	19	5	97
Central Provinces	245	107	37	389
Eastern Bengal and Assam	3	..	..	3
Madras	38	12	14	64
North-West Frontier Province . . . . .	..	1	1	2
Punjab	7	..	..	7
United Provinces	3	..	..	3
Total for each kind and Grand Total, 1909	394	143	156	693
<i>Totals for 1908</i>	<i>508</i>	<i>237</i>	<i>71</i>	<i>816</i>

E. L. denotes Exploring License; P. L., Prospecting License; and M. L., Mining Lease.

CLASSIFICATION OF LICENSES AND LEASES.**TABLE 21.—Prospecting and Mining Licenses granted in Baluchistan during 1909.**

DISTRICT.	1909.		
	No.	Area in acres.	Mineral.
Prospecting Licenses.			
Kalat	1	490	Coal.
Quetta-Pishin	2	12,800	Do.
Sibi	1	1,280	Do.
Total	4	..	
Mining Leases.			
Kalat	1	160	Coal.
Quetta-Pishin	4	320	Chromite.
Do.	16	2,610	Coal.
Sibi	2	320	Do.
Zhob	72	6,985·37	Chromite.
Total	95	..	

TABLE 22.—Prospecting and Mining Licenses granted in Bengal during 1909.

DISTRICT.	1909.		
	No.	Area in acres.	Mineral.
Prospecting Licenses.			
Hazaribagh	5	730	Mica.
Do.	2	2,000	Other minerals.
Sambalpur	1	424·38	Coal.
Singhbhum	1	2,291·20	Chromite.
Do.	1	2,240	Gold.
Do.	1	2,112	Manganese.
Total	11	..	
Mining Leases.			
Singhbhum	1	1,920	Iron ore.

TABLE 23.—*Prospecting and Mining Licenses granted in Bombay during 1909.*

DISTRICT.	1909.		
	No.	Area in acres.	Mineral.
Prospecting Licenses.			
Belgaum	3	1,572	Manganese.
Bijapur	1	765	Asbestos.
Do.	1	1,992	Gold.
Kanara	2	2,802	Manganese, etc.
Ratnagiri	1	508	Chromite.
Do.	1	632	Graphite, etc.
Do.	1	475	Mica and coal.
Total	10	..	

Mining Leases.			
Dharwar	2	2,383	Gold.
Panch Mahals	1	401	Manganese.
Total	3	..	

TABLE 24.—*Prospecting and Mining Licenses granted in Burma during 1909.*

DISTRICT.	1909.		
	No.	Area in acres.	Mineral.
Prospecting Licenses.			
Amherst	1	309' 14	Antimony.
Henzada	2	5,120	Coal.
Do.	1	1,920	Petroleum.
Katha	1	2,880	Copper.
Lower Chindwin	1	14' 09	Iron pyrites.
Magwe	4	15,643	Petroleum.
Mandalay	1	484' 8	All minerals except petroleum.
Carried over	11	..	

TABLE 24.—*Prospecting and Mining Licenses granted in Burma during 1909—contd.*

DISTRICT.	1909.		
	No.	Area in acres.	Mineral.
Prospecting Licenses—<i>contd.</i>			
Brought forward	11		
Mandalay	1	2,560	Copper, etc.
Do.	1	2,560	Lead, etc.
Do.	1	1,280	Silver.
Meiktila	1	7,680	Petroleum.
Do.	2	2,560	Lead and copper.
Do.	1	2,880	Coal.
Mergui	1	6,362·88	Tin.
Do.	9	16,000	Tin and gold.
Do.	1	2,611·2	Coal.
Minbu	2	4,480	Petroleum.
Myingyan	10	19,194	Do.
Myitkyina	1	640	Copper, etc.
N. Shan States	1	502·65	Coal.
Do.	2	952	Lead, silver, etc.
Pakokku	9	17,920	Petroleum.
Prome	2	30,380·8	Do.
Sagaing	1	550·96	Iron ore.
Salween	2	5,760	Lead and silver.
Shwebo	1	320	Iron ore.
S. Shan States	2	4,800	Copper, etc.
Do.	1	3,200	Lead, copper, etc.
Do.	2	5,120	Wolfram.
Tavoy	2	3,520	Tin, wolfram, etc.
Thaton	2	6,400	Gold etc.
Do.	1	2,560	Lead and silver.
Toungoo	2	4,549	Lead, silver, etc.
Upper Chindwin	1	5,760	Petroleum
Total	73	..	

Mining Leases.

Bhamo	1	1,568	Gold.
Magwo	1	688	Petroleum.
Pakokku	1	1,280	Do.
S. Shan States	1	7·38	Lead and silver.
Upper Chindwin	1	1,920	Coal.
Total	5	..	

TABLE 25.—*Prospecting and Mining Licenses granted in the Central Provinces during 1909.*

DISTRICT.	1909.		
	No.	Area in acres.	Mineral.
Prospecting Licenses.			
Balaghat	21	7,383	Manganese.
Do.	1	285	Mica.
Betul	5	9,391	Coal.
Do.	1	8,890	Coal, copper, etc.
Do.	2	610	Graphite.
Do.	1	148	Manganese.
Bhandara	70	14,328	Do.
Do.	1	1,300	Manganese, tin, etc.
Chanda	2	4,339	Coal.
Chhindwara	2	5,881	Do.
Do.	9	899	Manganese.
Drug	1	167	Lead and quick-silver.
Jubbulpore	2	663	Bauxite.
Do.	6	1,135	Manganese.
Do.	2	663	Manganese and iron.
Do.	1	633	Iron.
Do.	1	86	Coal.
Do.	2	863	Soapstone and talc.
Nagpur	90	15,086	Manganese.
Do.	12	3,850	Manganese and other minerals.
Do.	2	317	Lead ore.
Do.	1	53	Copper.
Do.	1	107	Mica.
Do.	1	231	Wolfram.
Raipur	2	1,479	Graphite.
Do.	1	114	Lead.
Do.	1	2,381	Manganese, etc.
Saugor	1	368	Gold, silver, etc.
Seoni	1	46	Manganese.
Do.	1	2,292	Iron ore.
Wardha	1	2,715	Coal.
Total	245		
Mining Leases.			
Balaghat	5	257	Manganese.
Bhandara	17	1,861	Do.
Chhindwara	2	41	Do.
Jubbulpore	1	49	Gold, silver, copper and lead.
Nagpur	12	761	Manganese.
Total	37		

TABLE 26.—*Prospecting Licenses granted in Eastern Bengal and Assam during 1909.*

DISTRICT.	1909.		
	No.	Area in acres.	Mineral.
Chittagong	1	2,675	Coal, oil, etc.
Lakhimpur	2	31,916	Coal, etc.
Total	3	..	

TABLE 27.—*Prospecting and Mining Licenses granted in Madras during 1909.*

DISTRICT.	1909.		
	No.	Area in acres.	Mineral.
Prospecting Licenses.			
Coimbatore	1	5,445.90	Corundum, asbestos, etc.
Do.	1	211.92	Mica.
Cuddapah	3	1,299.88	Lead ore.
Do.	1	30.60	Tin, lead, etc.
Do.	1	135.77	Gold.
Kurnool	1	2,267	Diamonds.
Do.	1	848.5	Diamonds, lead, etc.
Do.	1	600	Manganese.
Do.	2	957	Barytes.
Do.	1	2.18	All minerals.
Nellore	2	675	Mica.
Salem	1	12.97	Do.
Do.	1	107.04	Corundum and enomite.
Trichinopoly	1	4,522.77	Phosphatic nodules and gypsum.
Total	38	..	

Mining Leases.

Bellary	1	1,591.29	Manganese.
Nellore	13	551.92	Mica.
Total	14	..	

TABLE 28.—*Mining Leases granted in the North-West Frontier Province during 1909.*

DISTRICT.	No.	Area in acres.	Mineral.
Hazara	1	19' 14	Coal.

TABLE 29.—*Prospecting Licenses granted in the Punjab during 1909.*

DISTRICT.	No.	Area in acres.	Mineral.
Jhelum	2	147' 38	Coal.
Mianwali	2	2,798	Do.
Shahpur	3	760' 16	Do.
Total .	7	..	

TABLE 30.—*Prospecting Licenses granted in the United Provinces during 1909.*

DISTRICT.	No.	Area in acres.	Mineral.
Jhansi	3	2,093' 9	Copper, lead, etc.

TABLE 31.—*Summary of concessions granted in Government lands during the ten years 1900-1909.*

YEAR.	Mining and Prospecting Licenses.	Exploring Licenses.	TOTAL.
1900	61	11	72
1901	89	15	104
1902	89	16	105
1903	84	16	100
1904	125	26	151
1905	145	44	189
1906	211	41	252
1907	539	61	600
1908	579	237	816
1909	550	143	692

- Part 2 (out of print).—*Rocks of the Lower Godavari. 'Atgarh Sandstones' near Outback. Fossil flora in India. New or rare mammals from the Siwalika. Arvali series in North-Eastern Rajputana. Borings for coal in India. Geology of India.
- Part 3 (out of print).—*Tertiary zone and underlying rocks in North-West Punjab. Fossil floras in India. Erratics in Potwar. Coal explorations in Darjiling district. Limestones in neighbourhood of Barakar. Forms of blowing-machine used by smiths of Upper Assam. Analyses of Raniganj coals.
- Part 4.—*Geology of Mahanadi basin and its vicinity. Diamonds, golds, and lead ores of Sambalpur district. 'Eryon Comp. Barrovenais,' McCoy, from Supermatur group near Madras. Fossil floras in India. The Blaini group and 'Central Gneiss' in Simla Himalayas. Tertiaries of North-West Punjab. Genera *Choromeryx* and *Rhagatherium*.

Vol. XI, 1878.

- Part 1.—*Annual report for 1887. Geology of Upper Godavari basin, between river Wardha and Godavari, near Sironcha. Geology of Kashmir, Kishtwar, and Pangi. Siwalik mammals. Palaeontological relations of Gondwana system. 'Erratics in Punjab.'
- Part 2.—*Geology of Sind (second notice). Origin of Kumaun lakes. Trip over Milam Pass, Kumaun. Mud volcanoes of Ramri and Cheduba. Mineral resources of Ramri, Cheduba and adjacent islands.
- Part 3.—*Gold industry in Wynaad. Upper Gondwana series in Trichinopoly and Nellore-Kistna districts. Senarmontite from Sarawak.
- Part 4.—*Geological distribution of fossil organisms in India. Submerged forest on Bombay Island.

Vol. XII, 1879.

- Part 1.—*Annual report for 1878. Geology of Kashmir (third notice). Siwalik mammalia. Siwalik birds. Tour through Hangraug and Spiti. Mud eruption in Ramri Island (Arakan). Braunite, with Rhodonite, from Nagpur, Central Provinces. Palaeontological notes from Satpura coal basin. Coal importations into India.
- Part 2.—*Mohpani coal-field. Pyrolusite with Psilomelane at Gosaiapur, Jabalpur district. Geological reconnaissance from Indus at Kushalgarh to Kurram at Thal on Afghan frontier. Geology of Upper Punjab.
- Part 3.—*Geological features of northern Madura, Pudukota State, and southern parts of Tanjore and Trichinopoly districts included within limits of sheet 80 of Indian Atlas. Cretaceous fossils from Trichinopoly district, collected in 1877-78. *Sphenophyllum* and other *Equisetaceae* with reference to Indian form *Trizygia Speciosa*, Royle (*Sphenophyllum Trizygia*, Ung.). Mysorin and Atacamite from Nellore district. *Oorundum* from Khasi Hills. Joga neighbourhood and old mines on Nerbudda.
- Part 4.—*'Attock Slates' and their probable geological position. Marginal bone of undescribed tortoise, from Upper Siwaliks, near Nila, in Potwar, Punjab. Geology of North Arcot district. Road section from Murree to Abbottabad.

Vol. XIII, 1880.

- Part 1.—*Annual report for 1879. Geology of Upper Godavari basin in neighbourhood of Sironcha. Geology of Ladak and neighbouring districts. Teeth of fossil fishes from Ramri Island and Punjab. Fossil genera *Nöggerathia*, Stbg., *Nöggerathiopsis*, Fstm., and *Rhiptozamites*, Schmalh., in palaeozoic and secondary rocks of Europe, Asia, and Australia. Fossil plants from Kattywar, Shekh Budin, and Sirgujan. Volcanic foci of eruption in Konkan.
- Part 2.—*Geological notes. Palaeontological notes on lower trias of Himalayas. Artesian wells at Pondicherry, and possibility of finding sources of water-supply at Madras.
- Part 3.—*Kumaun lakes. Celt of palaeolithic type in Punjab. Palaeontological notes from Karharbari and South Rewa coal-fields. Correlation of Gondwana flora with other floras. Artesian wells at Pondicherry. Salt in Rajputana. Gas and mud eruptions on Arakan coast on 12th March 1879 and in June 1883.
- Part 4.—*Pleistocene deposits of Northern Punjab, and evidence they afford of extreme climates during portion of that period. Useful minerals of Arvali region. Correlation of Gondwana flora with that of Australian coal-bearing system. Reh or alkali soils and saline low waters. Reh soils of Upper India. Naini Tal landlip, 18th September 1880.

Vol. XIV, 1881.

- Part 1.—*Annual report for 1880. Geology of part of Dardistan, Baltistan, and neighbouring districts. Siwalik carnivora. Siwalik group of Sub-Himalayan region. South Rawah Gondwana basin. Ferruginous beds associated with basaltic rocks of north-eastern Ulatar, in relation to Indian laterite. Rajmahal plants. Travelled blocks of the Punjab. Appendix to 'Palaeontological notes on lower trias of Himalayas.' Mammalian fossils from Perim Island.

Part 2.—Nasir Siwalik unconformity in North-Western Himalaya. Gondwana vertebrates. Gneissous beds of Huedes in Tibet. Mining records and mining reports of Great Britain; and Coal and Metalliferous Mines Acts of 1872 (England). Cobaltite and daseite from Khatri mines, Rajputana; with remarks on Jaipurite (Synchroite). Zinc-ore (Smithsonite and Blende) with barytes in Karnul district, Madras. Mud eruption in island of Cheduba.

Part 3.—Artesian borings in India. Oligoclase granite at Wangtu on Sulej, North-West Himalayas. Fish-pellets from Siwalik. Paleontological notes from Hamirpoh and Lohardugga districts. Fossil carnivora from Siwalik hills.

Part 4.—Unification of geological nomenclature and cartography. Geology of Arvali region, central and eastern. Native antimony obtained at Pulo Obia, near Singapore. Turquoise from Juggiapett, Kistnah district, and zinc carbonate from Karnul, Madras. Section from Dalhousie to Pangri, *via* Sach Pass. South Rewah Gondwana basin. Submerged forest on Bombay Island.

VOL. XV, 1882.

Part 1 (out of print).—Annual report for 1881. Geology of North-West Kashmir and Khasan. Gondwana labyrinthodonta. Siwalik and Jamna mammals. Geology of Dalhousie, North-West Himalaya. Palm leaves from (tertiary) Murree and Kasauli beds in India. Iridosmine from Nos-Dihing river, Upper Assam, and Platinum from Chutia Nagpur. On (1) copper mine near Yongri hill, Darjiling district; (2) arsenical pyrites in same neighbourhood; (3) kolin at Darjiling. Analyses of coal and fire-clay from Makum coal field, Upper Assam. Experiments on coal of Pind Dadun Khan, Salt-range, with reference to production of gas, made April 29th, 1881. Proceedings of International Congress of Bologna.

Part 2 (out of print).—Geology of Travancore State. Warkilli beds and reported associated deposits at Quilon, in Travancore. Siwalik and Narbada fossils. Coal-bearing rocks of Upper Rer and Mand rivers in Western Chutia Nagpur. Panch river coal-field in Chhindwara district, Central Provinces. Borings for coal at Engsein, British Burma. Sapphires in North Western Himalaya. Eruption of mud volcanoes in Cheduba.

Part 3.—Coal of Mach (Mugh) in Bolan Pass, and of Sharigh on Harnai route between Sibi and Quetta. Crystals of stilbite from Western Ghats, Bombay. Traps of Darang and Mandi in North-Western Himalayas. Connexion between Hazara and Kashmir series. Umaria coal-field (South Rewah Gondwana basin) Darangiri coal-field, Garo Hills, Assam. Coal in Myanong division, Henzada district.

Part 4 (out of print).—Gold fields of Mysore. Borings for coal at Beddadanol, Godavari district, in 1874. Supposed occurrence of coal on Kistna

VOL. XVI, 1883.

Part 1.—Annual report for 1882. Richtigofenia, Kays (Anomia Lawrenciana, Koinck) Geology of South Travancore. Geology of Chamba. Basalts of Bombay.

Part 2.—Synopsis of fossil vertebrata of India. Bijori Labyrinthodont. Skull of Hippotherium antilopinum. Iron ores, and subsidiary materials for manufacture of iron, in north-eastern part of Jabalpur district. Laterite and other manganese ore occurring at Gosulpore, Jabalpur district. Umaria coal field.

Part 3.—Microscopic structure of some Dalhousie rocks. Lavas of Aden. Probable occurrence of Siwalik strata in China and Japan. Mastodon angustidens in India. Traverse between Almora and Mussooree. Cretaceous coal measures at Borsora, in Khasia Hills, near Lachur, in Sylhet.

Part 4.—Paleontological notes from Daltonganj and Hutar coal-fields in Chota Nagpur. Altered basalts of Dalhousie region in North-Western Himalayas. Microscopic structure of some Sub Himalayan rocks of tertiary age. Geology of Jaunsar and Lower Himalayas. Traverse through Eastern Khasia, Jaintia, and North Cachar Hills. Native lead from Maulmain and chromite from the Andaman Islands. Every eruption from one of mud volcanoes of Cheduba Island, Arakan. Irrigation from wells in North-Western Provinces and Oudh.

VOL. XVII, 1884.

Part 1.—Annual report for 1883. Smooth water anchorages or mud-banks of Naryakel and Alleppy on Travancore coast. Bills Surgam and other caves in Kurumb district. Geology of Chaugari and Sibhanta parganas of Chamba. Lyttania, Waagen, in Kashmir series of Kashmir.

Part 2.—Earthquake of 31st December 1881. Microscopic structure of some Himalayan granites and gneissose granites. Coal exploration. Re-discovery of fossils in Siwalik beds. Mineral resources of the Andaman Islands in neighbourhood of Port Blair. Intertrappean beds in Deccon and Laramie group in Western North America.

- Part 2 (out of print).—*Microscopic structure of some Arvali rocks. Section along Indus from Peshawar Valley to Salt-range. Sites for boring in Raigarh-Kingir coal-field (first notice). Lignite near Raipore, Central Provinces. Turquoise mines of Nishapur, Khorassan. Fiery eruption from Minhyia mud volcano of Cheduba Island, Arakan. Lignite coal-field, South-Western Khasia Hills. Umaria coal-field.
- Part 4.—*Geology of part of Gangaian pargana of British Garhwal. Slates and schists imbedded in gneissous granite of North-West Himalayas. Geology of Takht-i-Sultman. Smooth-water anchorages of Travancore coast. Auriferous sands of the Subansiri river, Pondicherry lignite, and phosphatic rocks at Musuri. Billa Surgam caves.

Vol. XVIII, 1885.

- Part 1.—*Annual report for 1884. Country between Singareni coal-field and Kistna river. Geological sketch of country between Singareni coal-field and Hyderabad. Coal and limestone in Dolgrung river near Golaghat, Assam. Homotaxis, as illustrated from Indian formations. Afghan field notes.
- Part 2.—*Fossiliferous series in Lower Himalaya, Garhwal. Age of Mandhali series in Lower Himalaya. Siwalik camel (*Camelus Antiquus*, nobis ex Falc. and Oaut. MS.). Geology of Chamba. Probability of obtaining water by means of artesian wells in plains of Upper India. Artesian sources in plains of Upper India. Geology of Aka Hills. Alleged tendency of Arakan mud volcanoes to burst into eruption most frequently during rains. Analyses of phosphatic nodules and rock from Mussooree.
- Part 3.—*Geology of Andaman Islands. Third species of *Merycopotamus*. Percolation as affected by current. Pirthalla and Chandpur meteorites. Oil-wells and coal in Thayetmyo district, British Burma. Antimony deposits in Maulmain district. Kashmir earthquake of 30th May 1885. Bengal earthquake of 14th July 1885.
- Part 4.—*Geological work in Chhattisgarh division of Central Provinces. Bengal earthquake of 14th July 1885. Kashmir earthquake of 30th May 1885. Excavations in Billa Surgam caves., Nepallite. Sabetmahet meteorite.

Vol. XIX, 1886.

- Part 1.—*Annual report for 1886. International Geological Congress of Berlin. Palaeozoic Fossils in Olive group of Salt-range. Correlation of Indian and Australian coal-bearing beds. Afghan and Persian Field notes. Section from Simla to Wangtu, and petrological character of Amphibolites and Quartz Diorites of Sutlej valley.
- Part 2.—*Geology of parts of Bellary and Anantapur districts. Geology of Upper Dehing basin in Singpho Hills. Microscopic characters of eruptive rocks from Central Himalayas. Mammals of Karnul Caves. Prospects of finding coal in Western Rajputana. Olive group of Salt-range. Boulder-beds of Salt-range. Gondwana Homotaxis.
- Part 3.—*Geological sketch of Vizagapatam district, Madras. Geology of Northern Jesalmer. Microscopic structure of Malani rocks of Arvali region. Malanjhandi copper-ore in Balaghat district, C. P.
- Part 4 (out of print).—*Petroleum in India. Petroleum exploration at Khātan. Boring in Chhattisgarh coal-fields. Field-notes from Afghanistan: No. 3, Turkistan. Fiery eruption from one of mud volcanoes of Cheduba Island, Arakan. Nammianthal aerolite. Analysis of gold dust from Meza valley, Upper Burma.

Vol. XX, 1887.

- Part 1.—*Annual report for 1886. Field-notes from Afghanistan: No. 4, from Turkistan to India. Physical geology of West British Garhwal; with notes on a route traversed through Jaunsar-Bawar and Tiri-Garhwal. Geology of Garo Hills. Indian image-stones. Soundings recently taken off Barren Island and Narcondam. Talchir boulder-beds. Analysis of Phosphatic Nodules from Salt-range, Punjab.
- Part 2.—*Fossil vertebrate of India. Echinoidea of cretaceous series of Lower Narbada Valley. Field-notes: No. 5—to accompany geological sketch map of Afghanistan and North-Eastern Khorassan. Microscopic structure of Rajmahal and Deccan traps. Dolomite of Chor. Identity of Olive series in east with speckled sandstone in west of Salt-range in Punjab.
- Part 3.—*Retirement of Mr. Medlicott. J. B. Mushketoff's Geology of Russian Turkistan. Crystalline and metamorphic rocks of Lower Himalaya, Garhwal, and Kumaon, Section I. Geology of Simla and Jutogh. 'Lalitpur' meteorite.
- Part 4.—*Points in Himalayan geology. Crystalline and metamorphic rocks of Lower Himalaya, Garhwal, and Kumaon, Section II. Iron industry of western portion of Raipur. Notes on Upper Burma. Boring exploration in Chhattisgarh coal-fields. (Second notice). Pressure Metamorphism, with reference to foliation of Himalayan Gneissous Granite. Papers on Himalayan Geology and Microscopic Petrology.

Vol. XXI, 1888.

- Part 2.*—Annual report for 1887. Crystalline and metamorphic rocks of Eastern Himalayas, Garhwal, and Kumaun, Section III. Birds' nest of Elephant Island, Indian Archipelago. Exploration of Jessalmer, with a view to discovery of coal. Fossils from boulder bed ('speckled sandstone') of Mount Omet in Salt-range. Nodular stones obtained off Colombo.
- Part 3.*—Award of Wollaston Gold Medal, Geological Society of London, 1888. Dharwar System in South India. Igneous rocks of Raipur and Balaghat, Central Provinces, Sangar-Marg and Mehowale coal-fields, Kashmir.
- Part 5.*—Manganese Iron and Manganese Ores of Jabalpur. 'The Carboniferous Glacial Period.' Pre-tertiary sedimentary formations of Simla region of Lower Himalayas.
- Part 4.*—Indian fossil vertebrates. Geology of North-West Himalayas. Blown sand rock sculpture. Nummulites in Zanakar. Mica traps from Barakar and Raniganj.

Vol. XXII, 1889.

- Part 1 (out of print).*—Annual report for 1888. Dharwar System in South India. Wajra Karur diamonds, and M. Chaper's alleged discovery of diamonds in pegmatite. Generic position of so-called *Plesiosaurus Indicus*. Flexible sandstone or Itacolmitite, its nature, mode of occurrence in India, and cause of its flexibility. Siwalik and Narbada Chelonia.
- Part 2.*—Indian Steatite Distorted pebbles in Siwalik conglomerate. 'Carboniferous Glacial Period.' Notes on Dr W. Waagen's "Carboniferous Glacial Period." Oil-fields of Twingoung and Beme, Burma. Gypsum of Nehal Nadi, Kumaun. Materials for pottery in neighbourhood of Jabalpur and Umaria.
- Part 3.*—Coal outcrops in Sharigh Valley, Baluchistan. Trilobites in Neobolus beds of Salt-range. Geological notes. Cherra Poonjee coal-field, in Khasia Hills, Cobaltiferous Matt from Nepal. President of Geological Society of London on International Geological Congress of 1888. Tin-mining in Mergui district.
- Part 4 (out of print).*—Land-tortoises of Siwaliks. Pelvis of a ruminant from Siwaliks. Assays from Sambhar Salt-Lake in Rajputana. Manganiferous iron and Manganese Ores of Jabalpur. Palagonite-bearing traps of Rajmahal hills and Deccan. Tin-smelting in Malay Peninsula. Provisional Index of Local Distribution of Important Minerals, Miscellaneous Minerals, Gem Stones and Quarry Stones in Indian Empire.
- Part 1.*

Vol. XXIII, 1890

- Part 1.*—Annual report for 1889. Lakadong coal-fields, Jaintia Hills. Pectoral and pelvic girdles and skull of Indian *Dicynodonts*. Vertebrate remains from Nagpur district (with description of fish-skull). Crystalline and metamorphic rocks of Lower Himalayas, Garhwal and Kumaun, Section IV. Bivalves of Olive-group, Salt-range. Mud-banks of Travancore coast.
- Part 2 (out of print).*—Petroleum explorations in Harnai district, Baluchistan. Sapphire Mines of Kashmir. Supposed Matrix of Diamond at Wajra Karur, Madras. Sonapat Gold-field. Field notes from Shan Hills (Upper Burma). New species of *Syringosphenridae*.
- Part 3 (out of print).*—Geology and Economic Resources of Country adjoining Sind-Pishin Railway between Sharigh and Spintangi, and of country between it and Khattan. Journey through India in 1888-89, by Dr. Johannes Walther. Coal fields of Lairungao, Maosandram, and Mao be-lar-kar, in the Khasi Hills. Indian Steatite. Provisional Index of Local Distribution of Important Minerals, Miscellaneous Minerals, Gem Stones, and Quarry Stones in Indian Empire.
- Part 4 (out of print).*—Geological sketch of Naini Tal; with remarks on natural conditions governing mountain slopes. Fossil Indian Bird Bones. Darjiling Coal between Lissu and Ramthi rivers. Basic Eruptive Rocks of Kadappa Area. Deep Boring at Lucknow. Coal Seam of Dore Ravine, Hazara.

Vol. XXIV, 1891.

- Part 1.*—Annual report for 1890. Geology of Salt-range of Punjab, with re-considered theory of Origin and Age of Salt-Marl. Graphite in decomposed Gneiss (Lafayette) in Ceylon. Glaciers of Kabre, Pandim, etc. Salts of Sambhar Lake in Rajasthan, and 'Beh' from Aligarh in North-Western Provinces. Analysis of Dolomite from Salt-range, Punjab.
- Part 2.*—Oil near Moghal Kot, in Sherahi country, Sulaiman Hills. Mineral Oil from Sulaiman Hills. Geology of Lushai Hills. Gem-stones in Northern Shan States. Reported Namsaka Ruby-mine in Maiting State. Tourmaline (Rubic) Mines in Maiting State. Salt-spring near Bawgyo, Tibetan State.

- Part 2.—Fossils of Ganges in Chittagong, Dacca, Patanow. Death of Dr. P. Martin.
 Part 3.—Geological map of Ganges and Sonolite-bearing Rocks.
 Part 4.—Mineralogical Essays from Mongolia. Dargling Coal Exploration. Geology and Mineral Resources of Sikim. Rocks from the Salt-range, Punjab.

VOL. XXV, 1892.

- Part 1.—Annual report for 1891. Geology of Thak Chotiali and part of Mari country. Petrological Notes on Boudhast of Salt-range, Punjab. Sub-recent and Recent Deposits of valley plains of Quetta, Pishin, and Lasht-i-Bedaolat; with appendices on Chamaus of Quetta; and Artesian water-supply of Quetta and Pishin.
 Part 2 (out of print).—Geology of Baluch Koh. Jherria Coal-field.
 Part 3.—Locality of Indian Tachyphallus. Geological Sketch of country north of Bhamo. Economic resources of Amber and Jade mines area in Upper Burma. Iron-ores and Iron Industries of Salem District. Hibaekite in India. Coal on Great Tenasserim River, Lower Burma.
 Part 4.—Oil Springs at Moghal Kot in Shirani Hills. Mineral Oil from Suleiman Hills. New Amber-like Resin in Burma. Triassic Deposits of Salt-range.

VOL. XXVI, 1893.

- Part 1.—Annual report for 1892. Central Himalayas. Jadeite in Upper Burma. Burmite, new Fossil Resin from Upper Burma. Prospecting Operations, Mergui District, 1891-92.
 Part 2.—Earthquake in Baluchistan on 20th December 1892. Burmite, new amber-like fossil resin from Upper Burma. Alluvial deposits and Subterranean water-supply of Rangoon.
 Part 3.—Geology of Shirani Hills. Carboniferous Fossils from Tenasserim. Boring at Chandernagore. Granite in Tavoy and Mergui.
 Part 4.—Geology of country between Chappar Rift and Harnai in Baluchistan. Geology of part of Tenasserim Valley with special reference to Tendau-Kamapying Coal-field. Magnetite containing Manganese and Alumina. Hsiolipite.

VOL. XXVII, 1894.

- Part 1.—Annual report for 1893. Bhaganwala Coal-field, Salt-range, Punjab.
 Part 2.—Petroleum from Burma. Singareni Coal field, Hyderabad (Deccan). Gohna Landship, Garhwal.
 Part 3.—Cambrian Formation of Eastern Salt-range. Giridih (Karharbari) Coal-fields. Chipped (?) Flints in Upper Miocene of Burma. Velates Schmidellana, Chamm., and Provelates grandis, Sow. sp., in Tertiary Formation of India and Burma.
 Part 4.—Geology of Wuntho in Upper Burma. Echinoids from Upper Cretaceous System of Baluchistan. Highly Phosphatic Mica Peridotites intrusive in Lower Gondwana Rocks of Bengal. Mica-Hypersthene-Hornblende-Peridotite in Bengal.

VOL. XXVIII, 1895.

- Part 1.—Annual report for 1894. Cretaceous Formation of Pondicherry. Early alluvium to Barren Island. Bibliography of Barren Island and Narcondam from 1894 to 1894.
 Part 2.—Cretaceous Rocks of Southern India and geographical conditions during latest cretaceous times. Experimental Boring for Petroleum at Sukjur from October 1893 to March 1895. Tertiary system in Burma.
 Part 3.—Jadeite and other rocks, from Tamraw in Upper Burma. Geology of Tochi Valley. Lower Gondwanas in Argentina.
 Part 4.—Igneous Rocks of Giridih (Kharharbari) Coal-field and their Contact Effects. Vindhyan system south of Sone and their relation to so-called Lower Vindhyan. Lower Vindhyan area of Sone Valley. Tertiary system in Burma.

VOL. XXIX, 1896.

- Part 1.—Annual report for 1895. Acicular inclusions in Indian Garnets. Origin and Growth of Garnets and of their Micropegmatitic intergrowths in Pyroxenic rocks.
 Part 2.—Ultra-basic rocks and derived minerals of Chalk (Magnesian) hills, and other localities near Salem, Madras. Cerundum localities in Salem and Coimbatore districts, Madras. Gornadum and Kyanite in Manbhurn district, Bengal. Ancient Geography of "Gondwanaland." Notes.
 Part 3.—Igneous Rocks from the Tochi Valley. Notes.
 Part 4.—Jadeite mines, Mithun district, Burma. Lower Vindhyan (Sub-Kaimur) area of Sone Valley, Bihar. Notes.

VOL. XXX, 1897.

- Part 1.—Annual report for 1896. Nephite and associated Basic Dykes and Lava-flows in Southern India. Genus Vertebraria. On Glossopterus and Vertebraria.

Part 2.—Cretaceous Deposits of Pondicherry. Notes.

Part 3.—Flow structure in igneous dykes at Coonoor. Excavations for corundum near Palakod, Salem District. Occurrence of coal at Palana in Bilaspur. Geological specimens collected by Afghan-Baluch Boundary Commission of 1896.

Part 4.—Nematite from Afghanistan. Quartz-barytes rock in Salem district, Madras Presidency. Worn femur of *Hippopotamus iravadicus*, Caut. and Falc., from Lower Pliocene of Burma. Supposed coal at Jaintia, Baza Duars. Percussion Figures on micas. Notes.

VOL. XXXI, 1904.

Part 1 (out of print).—Prefatory Notice. Copper-ore near Komai, Darjeeling district. Zewan beds in Vihri district, Kashmir. Coal deposits of Isa Khal, Mianwali district, Punjab. Um-Rileng coal-beds, Assam. Sapphirine-bearing rock from Vizagapatam district. Miscellaneous Notes. Assays.

Part 2 (out of print).—Lt.-Genl. C. A. McMahon. *Cyclobus Haydeni* Diener. Auriferous Occurrences of Chota Nagpur, Bengal. On the feasibility of introducing modern methods of Coke-making at East Indian Railway Collieries, with supplementary note by Director, Geological Survey of India. Miscellaneous Notes.

Part 3 (out of print).—Upper Palaeozoic formations of Eurasia. Glaciation and History of Sind Valley. Halorites in Trias of Baluchistan. Geology and Mineral Resources of Mayurbhanj. Miscellaneous Notes.

Part 4 (out of print).—Geology of Upper Assam. Auriferous Occurrences of Assam. Curious occurrence of Scapolite from Madras Presidency. Miscellaneous Notes. Index.

VOL. XXXII, 1905.

Part 1 (out of print).—Review of Mineral Production of India during 1898—1903.

Part 2 (out of print).—General report, April 1903 to December 1904. Geology of Provinces of Tsang and U in Tibet. Bauxite in India. Miscellaneous Notes.

Part 3 (out of print).—Anthracolithic Fauna from Subansiri Gorge, Assam. *Elephas Antiquus* (Namadicus) in Godavari Alluvium. Triassic Fauna of Tropites-Limestone of Byans. Amblygonite in Kashmir. Miscellaneous Notes.

Part 4.—Obituary notices of H. B. Medlicott and W. T. Blanford. Kangra Earthquake of 4th April 1905. Index to Volume XXXII.

VOL. XXXIII, 1906.

Part 1 (out of print).—Mineral Production of India during 1904. Pleistocene Movement in Indian Peninsula. Recent Changes in Course of Nam-tu River, Northern Shan States. Natural Bridge in Gokteik Gorge. Geology and Mineral Resources of Narnaul District (Patiala State). Miscellaneous Notes.

Part 2 (out of print).—General report for 1905. Lashio Coal-field, Northern Shan States. Namma, Mansang and Man-se-le Coal-fields, Northern Shan States, Burma. Miscellaneous Notes.

Part 3 (out of print).—Petrology and Manganese-ore Deposits of Sansar Tahsil, Chhindwara district, Central Provinces. Geology of part of valley of Kanhan River in Nagpur and Chhindwara districts, Central Provinces. Manganite from Sandur Hills. Miscellaneous Notes.

Part 4 (out of print).—Composition and Quality of Indian Coals. Classification of the Vindhyan System. Geology of State of Panna with reference to the Diamond-bearing Deposits. Index to Volume XXXIII.

VOL. XXXIV, 1906.

Part 1.—Fossils from Halorites Limestone of Bambagan Cliff, Kumaon. Upper-Triassic Fauna from Pishin District, Baluchistan. Geology of portion of Bhutan. Coal Occurrences in Foot-hills of Bhutan. Dandli Coal-field: Coal outcrops in Kotli Tehsil of Jammu State. Miscellaneous Notes.

Part 2 (out of print).—Mineral Production of India during 1905. *Nummulites Douvillei*, with remarks on Zonal Distribution of Indian *Nummulites*. Auriferous Tracts in Southern India. Abandonment of Collieries at Warora, Central Provinces. Miscellaneous Notes.

Part 3.—Explosion Craters in Lower Chindwin district, Burma. Lavas of Pavagad Hill. Gibbsite with Manganese-ore from Talevadi, Belgaum district, and Gibbsite from Bhokoli, Satar District. Classification of Tertiary System in Sind with reference to Zonal distribution of Eocene Echinoidea.

Part 4 (out of print).—Jaipur and Nazira Coal-fields, Upper Assam. Makum Coal-fields between Tirap and Namdang Streams. Kabat Anticline, near Seiktein, Myingyan district, Upper Burma. Asymmetry of Yenangyat-Singn Anticline, Upper Burma. Northern part of Gwegyo Anticline, Myingyan District, Upper Burma. *Bryozoa* Multituberculata, from Nari of Baluchistan and Sind. Index to Volume XXXIV.

Vol. XXXV, 1907.

- Part 1 (out of print).*—General report for 1906. Orthophragmina and Lepidocyclus in Nummulitic Series. Meteoric Shower of 22nd October 1903 at Dokachi and neighbourhood, Dacca district.
- Part 2.*—Indian Aerolites. Brine-wells at Bawgyo, Northern Shan States. Gold-bearing Deposits of Loi Twang, Shan States. *Physa Prinepii* in Maestrichtian strata of Baluchistan. Miscellaneous Notes.
- Part 3.*—Preliminary survey of certain Glaciers in North-West Himalaya. A.—Notes on certain Glaciers in North-West Kashmir.
- Part 4.*—Preliminary survey of certain Glaciers in North-West Himalaya. B.—Notes on certain Glaciers in Lahaul. C.—Notes on certain Glaciers in Kumaon. Index to Volume XXXV.

Vol. XXXVI, 1907-08.

- Part 1.*—Petrological Study of Rocks from hill tracts, Vizagapatam district, Madras Presidency. Nepheline Syenites from hill tracts, Vizagapatam district, Madras Presidency. Stratigraphical Position of Gangamopteris Beds of Kashmir. Volcanic outburst of Late Tertiary Age in South Hsenwi, N. Shan States. New sildes from Bugti Hills, Baluchistan. Permo-Carboniferous Plants from Kashmir.
- Part 2 (out of print).*—Mineral Production of India during 1906. Ammonites of Bagh Beds. Miscellaneous Notes.
- Part 3.*—Marine fossils in Yenangyaung oil-field, Upper Burma. Fresh-water shells of genus *Batissa* in Yenangyaung oil-field, Upper Burma. New Species of *Dendrophyllia* from Upper Miocene of Burma. Structure and age of Taungtha hills, Myingyan district, Upper Burma. Fossils from Sedimentary rocks of Oman (Arabia). Rubies in Kachin hills, Upper Burma. Cretaceous Orbitoides of India. Two Calcutta Earthquakes of 1906. Miscellaneous Notes.
- Part 4.*—Pseudo-Fucoids from Pah sandstones at Fort Munro, and from Vindhyan series. Jadeite in Kachin Hills. Upper Burma. Wetchok-Yedwet Pegu outcrop, Magwe district, Upper Burma. Group of Manganates, comprising Hollandite, Psilomelane and Coronadite. Occurrence of Wolfram in Nagpur district, Central Provinces. Miscellaneous Notes. Index to Volume XXXVI.

Vol. XXXVII, 1908-09.

- Part 1.*—General report for 1907. Mineral Production of India during 1907. Occurrence of striated boulders in Blaini formation of Simla. Miscellaneous Notes.
- Part 2.*—Tertiary and Post-Tertiary Freshwater Deposits of Baluchistan and Sind. Geology and Mineral Resources of Rajpipla State. Suitability of sands in Rajmahal Hills for glass manufacture. Three new Manganese-bearing minerals:—Vredenburgite, Sitaparite and Juddite. Laterites from Central Provinces. Miscellaneous Notes.
- Part 3.*—Southern part of Gwegyo Hills, including Payaggyigon-Ngashandaung Oil-field. Silver-lead mines of Bawdwin, Northern Shan States. Mud volcanoes of Arakan Coast, Burma.
- Part 4.*—Gypsum Deposits in Hamirpur district, United Provinces. Gondwanas and related marine sedimentary system of Kashmir. Miscellaneous Notes. Index to Volume XXXVII.

Vol. XXXVIII, 1909.

- Part 1.*—General report for 1908. Mineral Production of India during 1908.
- Part 2.*—*Ostrea latimarginata* in Burma. China-clay and Fire-clay of Rajmahal Hills. Coal at Gilhurria. Pegu Inlier at Ondwe. Salt Deposits of Rajputana. Miscellaneous Notes.
- Part 3.*—Geology of Sarawan, Jhalawan and Las Bela. Hippurite limestone in Seistan. Afghan Fusulinidae. Miscellaneous Notes.
- Part 4.*—Western Prome and Kama. Recorrelation of Pegu system. Pegu fossil fish-teeth. Yenangyat Oil-field. Iron-ores of Chanda. Geology of Aden Hinterland. Petrography of Aden Hinterland. Fossils from Aden Hinterland. Miscellaneous Notes. Index to Volume XXXVIII.

Vol. XXXIX, 1910.

Quinquennial Review of Mineral Production for 1904 to 1908.

Vol. XL, 1910.

- Part 1.*—Pre-Carboniferous Life-Provinces. Lakes of the Salt Range. Glaciers in Sikkim. New Tertiary mammals.

The price fixed for the publications is 1 rupee (1s. 4d.) each part, or 2 rupees (2s. 8d.) each volume of four parts.

MISCELLANEOUS PUBLICATIONS.

- A Manual of the Geology of India. 4 Vols. With map 1879-1887—
 Vol. 1. Peninsular Area. } By I. B. Medlicott and W. T. Blanford
 Vol. 2. Extra Peninsular Area. } (out of print).
 Vol. 3. Economic Geology. By V. Ball (out of print).
 Vol. 4. Mineralogy. By F. R. Mallet. Price 2 rupees.
 A Manual of the Geology of India, 2nd edition. By R. D. Oldham (1893). Price 6 rupees.
 A Manual of Geology of India, Economic Geology, by the late Prof. V. Ball, 2nd edition, revised in parts.
 Part I.—Overview. By T. H. Holland (1898). Price 1 rupee.
 Popular guides to the Geological collections in the Indian Museum. Calcutta—
 No. 1. Tertiary vertebrate animals. By R. Lydekker (1879) (out of print).
 No. 2. Minerals. By F. R. Mallet (1879) (out of print).
 No. 3. By F. Feeden (1880) (out of print).
 No. 4. Paleontological collections. By O. Feistmantel (1881). Price 2 annas.
 No. 5. Economic mineral products. By F. R. Mallet (1883) (out of print).
 An introduction of the Chemical and Physical study of Indian Minerals. By T. H. Holland (1895) (out of print).
 Catalogue of the remains of Siwalik Vertebrata contained in the Geological Department of the Indian Museum. By R. Lydekker, Pt. I. Mammalia (1885). Price 1 rupee.
 Pt. II. Aves, Reptilia, and Pisces (1886). Price 4 annas.
 Catalogue of the remains of Pleistocene and Pre-Historic Vertebrata contained in the Geological Department of the Indian Museum. By R. Lydekker (1886). Price 4 annas.
 Bibliography of Indian Geology. By R. D. Oldham (1888). Price 1 rupee 8 annas.
 Report on the geological structure and stability of the hill slopes around Naini Tal. By T. H. Holland (1897). Price 3 rupees.
 Geological map of India, 1893. Scale 1"=96 miles (out of print).
 General Report for the period from 1st January 1897 to the 1st April 1898. Price 1 rupee.
 General Report for the year 1898-99 (out of print).
 General Report for the year 1899-1900. Price 1 rupee.
 General Report for the year 1900-1901. Price 1 rupee.
 General Report for the year 1901-1902. Price 1 rupee.
 General Report for the year 1902-1903. Price 1 rupee.
 Sketch of the Mineral Resources of India. By T. H. Holland (1908). Price 1 rupee (out of print).
 Contents and index to Records, Vols. I-XX and Vols. XXI-XXIX. Price 1 rupee each.
 Contents and index to Memoirs, 1859-1883. (First twenty volumes). Price 1 rupee

GEOLOGICAL SURVEY OF INDIA.

Director.

SIR THOMAS H. HOLLAND, K.C.I.E., D.Sc., F.R.S. : A.R.C.S., F.G.S., F.A.S.B.

Superintendents.

TOM. D. LATOUCHE, B.A. (Cantab.), F.G.S., F.A.S.B. : C. S. MIDDLEMISS, B.A. (Cantab.), F.G.S.

H. H. HAYDEN, B.A., B.E. (T.C.D.), F.G.S.

Assistant Superintendents.

P. N. DATTA, B.Sc. (London) :

E. W. VREDENBURG, B.L., B.Sc. (France), A.R.S.M., A.R.C.S., F.G.S. :

L. IREIGH FERMOR, A.R.S.M., D.Sc. (London), F.G.S. :

GUY E. PILGRIM, D.Sc. (London), F.G.S. ; G. H. TIPPER, M.A. (Cantab.), F.G.S. :

H. WALKER, A.R.C.S., F.G.S., A.Inst.M.M. :

E. H. PASCOE, M.A. (Cantab.), B.Sc. (London), F.G.S. :

K. A. K. HALLOWES, B.A. (Cantab.), A.R.S.M., F.G.S., A. Inst. M.M. :

G. DE P. COTTER, B.A. (Dub.), F.G.S. :

J. CORGIN BROWN, B.Sc. (Dunelm), F.G.S., F.C.S., A.M.Inst.M.E. :

J. J. A. PAGE, A.R.S.M., A.I.M.M. (London) :

H. C. JONES, A.R.S.M., A.R.C.S., F.G.S. ; A. M. HERON, B.Sc. (Edin.), F.G.S. :

M. STUART, B.Sc. (Birmingham), F.G.S., F.C.S. :

N. D. DARU, B.Sc., B.A. (Bom.), B.Sc. (London), A.R.S.M., Bar-at-law.

Chemist.

W. A. K. CHRISTIE, B.Sc. (Edin.), Ph.D.

Sub-Assistant.

S. SETHU RAMA RAU, B.A. : M. VINAYAK RAO, B.A.

Artist.

H. B. W. GARRICK

Assistant Secretary.

T. R. BRYAN

Registrar.

A. E. MACAULAY AULDREY, F.Z.S.
 Geological Museum, Library, and Office, Calcutta.

RECORDS
OF
THE GEOLOGICAL SURVEY OF INDIA.

VOL. XL, PART III.

1910.

CONTENTS.

PAGES.

Preliminary Note on a Revised Classification of the Tertiary Freshwater Deposits of India. By Guy E. Pilgrim, D.Sc., F.G.S., Geological Survey of India . . .	185—205
A Revision of the Silurian-Trias Sequence in Kashmir. By C. S. Middlemiss, B.A., F.G.S., Superintendent, Geological Survey of India. (With Plates 28 to 39.)	206—260
Note on the Discovery by Mr. Middlemiss of Fenestella-bearing Beds in Kashmir. By H. H. Hayden, Superintendent, Geological Survey of India . . .	261—263

Published by order of the Government of India.

CALCUTTA:

SOLD AT THE OFFICE OF THE GEOLOGICAL SURVEY,
27, CHOWRINGHEE ROAD.

LONDON: MESSRS. KEGAN PAUL, TRENCH, TRÜBNER & CO.,
BERLIN: MESSRS. FRIEDLÄNDER UND SOHN.

1910

Price One Rupee per Part, or Five Rupees per Volume of 4 Parts.

MEMOIRS OF THE GEOLOGICAL SURVEY OF INDIA.

- VOL.** I. Pt. 1, 1856 (*out of print*) : Coal and Iron of Talchir.—Talchir Coal-field.—Gold-yielding deposits of Upper Assam.—Gold from Shuë-gween. Pt. 2, 1858 (*out of print*) : Geological structure of a portion of Khasi Hills.—Geological structure of Nilgiri Hills (Madras). Pt. 3, 1859 (*out of print*) : Geological structure and physical features of districts of Bankura, Midnapore, and Orissa.—Laterite of Orissa.—Fossil fish-teeth of genus *Ceratodus*, from Maledi, south of Nagpur.
- VOL.** II. Pt. 1, 1860 (*out of print*) : Vindhyan rocks, and their associates in Bundelkand. Pt. 2, 1860 (*out of print*) : Geological structure of central portion of Nerbudda District.—Tertiary and alluvial deposits of central portion of Nerbudda Valley.—Geological relations and probable age of systems of rocks in Central India and Bengal.
- VOL.** III. Pt. 1, 1863 (*out of print*) : Raniganj Coal-field.—Additional remarks on systems of rocks in Central India and Bengal.—Indian Mineral Statistics, I. Coal. Pt. 2, 1864 (*out of print*) : Sub-Himalayan Ranges between Ganges and Ravi.
- VOL.** IV. Pt. 1, 1863 (*out of print*) : Cretaceous Rocks of Trichinopoly District, Madras. Pt. 2, 1864 (*out of print*) : Districts of Trichinopoly, Salem, etc. Pt. 3, 1865 (*out of print*) : Coal of Assam, etc.
- VOL.** V. Pt. 1, 1865 (*out of print*) : Sections across N.-W. Himalaya, from Sutlej to Indus.—Gypsum of Spiti. Pt. 2, 1866 (*out of print*) : Geology of Bombay. Pt. 3, 1866 (*out of print*) : Jheria Coal-field.—Geological Observations on Western Tibet.
- VOL.** VI. Pt. 1, 1867 (*out of print*) : Neighbourhood of Lynyan, etc., in Sind.—Geology of portion of Cutch. Pt. 2, 1867, Rep. 1908 (*price* 2 Rs.) : Bokáro Coal-field.—Ramgarh Coal-field.—Traps of Western and Central India. Pt. 3, 1869 (*price* 2 Rs. 8 As.) : Tapti and Nerbudda Valleys.—Frog-beds in Bombay.—*Oxyglossus pusillus*.
- VOL.** VII. Pt. 1, 1869 (*price* 3 Rs.) : Vindhyan series.—Mineral Statistics.—Coal.—Shillong Plateau. Pt. 2, 1870 (*out of print*) : Karharbári Coal-field.—Deoghar Coal-field. Pt. 3, 1871 (*out of print*) : Aden water-supply.—Káranpura Coal-fields.
- VOL.** VIII. Pt. 1, 1872 (*price* 4 Rs.) : Kadapah and Karnul Formations in Madras Presidency. Pt. 2, 1872 (*price* 1 Re.) : Itkhuri Coal-field.—Daltonganj Coal-field.—Chope Coal-field.
- VOL.** IX. Pt. 1, 1872 (*out of print*) : Geology of Kutch. Pt. 2, 1872 (*price* 1 Re.) : Geology of Nagpur.—Geology of Sirban Hill.—Carboniferous Ammonites.
- VOL.** X. Pt. 1 (*price* 3 Rs.) : Geology of Madras.—Sátpura Coal-basin. Pt. 2, 1874 (*price* 2 Rs.) : Geology of Pegu.
- VOL.** XI. Pt. 1, 1874 (*price* 2 Rs.) : Geology of Dárrjiling and Western Duars. Pt. 2, 1876 (*price* 3 Rs.) : Salt-region of Kohát, Trans-Indus.
- VOL.** XII. Pt. 1, 1877 (*price* 3 Rs.) : South Mahrátta Country. Pt. 2, 1876 (*price* 2 Rs.) : Coal-fields of Nága Hills.
- VOL.** XIII. Pt. 1, 1877 (*price* 2 Rs. 8 As.) : Wardha Valley Coal-field. Pt. 2, 1877 (*price* 2 Rs. 8 As.) : Geology of Rájmahál Hills.
- VOL.** XIV. 1878 (*price* 5 Rs.) : Geology of Salt-range in Punjab.
- VOL.** XV. Pt. 1, 1878 (*price* 2 Rs. 8 As.) : Aurunga and Hutár Coal-fields (Palamow). Pt. 2, 1880 (*price* 2 Rs. 8 As.) : Ramkola and Tatapani Coal-fields (Sirguja).
- VOL.** XVI. Pt. 1, 1879 (*price* 1 Re. 8 As.) : Geology of Eastern Coast from Lat. 15° to Masulipatam. Pt. 2, 1880 (*price* 1 Re. 8 As.) : Nellore Portion of Carnatic. Pt. 3, 1880 (*price* 2 Rs.) : Coastal Region of Godávári District.
- VOL.** XVII. Pt. 1, 1879 (*price* 3 Rs.) : Geology of Western Sind. Pt. 2, 1880 (*price* 2 Rs.) : Trans-Indus extension of Punjab Salt-range.

- VOL. XVIII.** Pt. 1, 1881 (*price 2 Rs.*): Southern Afghanistan. Pt. 2, 1881 (*out of print*): Mánbhum and Singhbhum. Pt. 3, 1881 (*price 2 Rs.*): Fránhita, Godávari Valley.
- VOL. XIX.** Pt. 1, 1882 (*price 2 Rs.*): Cachar Earthquake of 1869. Pt. 2, 1882 (*price 1 Re.*): Thermal Springs of India. Pt. 3, 1883 (*price 1 Re.*): Catalogue of Indian Earthquakes. Pt. 4, 1883 (*out of print*): Geology of parts of Manipur and Naga Hills.
- VOL. XX.** Pt. 1, 1883 (*out of print*): Geology of Madura and Tinnevely. Pt. 2, 1883 (*out of print*): Geological notes on Hills in neighbourhood of Sind and Punjab Frontier between Quetta and Dera Ghazi Khan.
- VOL. XXI.** Pt. 1, 1884 (*out of print*): Geology of Lower Narbada Valley. Pt. 2, 1884 (*out of print*): Geology of Kathiawar. Pt. 3, 1885 (*out of print*): Coal-field of South Rewah. Pt. 4, 1885 (*out of print*): Barren Island.
- VOL. XXII.** 1883 (*price 5 Rs.*): Geology of Kashmir, Chamba, and Khagan.
- VOL. XXIII.** 1891 (*price 5 Rs.*): Geology of Central Himalayas.
- VOL. XXIV.** Pt. 1, 1887 (*out of print*): Southern Coal-fields of Sápura Gondwána basin. Pt. 2, 1890 (*out of print*): Geology of Sub-Himalaya of Garhwal and Kumaun. Pt. 3, 1890 (*out of print*): Geology of South Malabar, between Beypore and Ponnáni Rivers.
- VOL. XXV.** 1896 (*out of print*): Geology of Bellary District, Madras Presidency.
- VOL. XXVI.** 1896 (*out of print*): Geology of Hazara.
- VOL. XXVII.** Pt. 1, 1895 (*out of print*): Marine Fossils from Miocene of Upper Burma. Pt. 2, 1897 (*out of print*): Petroleum in Burma and its technical exploitation.
- VOL. XXVIII.** Pt. 1, 1898 (*price 2 Rs.*): Geological Structure of Chitichun region.—Allahbund in north-west of Rann of Kuchh.—Geology of parts of Myingyan, Magwè and Pakokku Districts, Burma.—Geology of Mikir Hills in Assam.—Geology of Tirah and Bazár Valley. Pt. 2, 1900 (*price 3 Rs.*): Charnockite Series, group of Archæan Hypersthenic Rocks in Peninsular India.
- VOL. XXIX.** 1900 (*price 5 Rs.*): Earthquake of 12th June 1897.
- VOL. XXX.** Pt. 1, 1900 (*price 2 Rs.*): Aftershocks of Great Earthquake of 12th June 1897. Pt. 2, 1900 (*price 1 Re.*): Geology of neighbourhood of Salem, Madras Presidency. Pt. 3, 1901 (*price 1 Re.*): Sivamalai Series of Elæolite-Syenites and Corundum Syenites. Pt. 4, 1901 (*price 1 Re.*): Geological Congress of Paris.
- VOL. XXXI.** Pt. 1, 1901 (*price 2 Rs.*): Geology of Son Valley in Rewah State and of Parts of Jabalpur and Mirzapur. Pt. 2, 1901 (*price 3 Rs.*): Baluchistan Desert and part of Eastern Persia. Pt. 3, 1901 (*price 1 Re.*): Peridotites, Serpentinés, etc., from Ladakh.
- VOL. XXXII.** Pt. 1, 1901 (*price 1 Re.*): Recent Artesian Experiments in India. Pt. 2, 1901 (*price 2 Rs.*): Rampur Coal field. Pt. 3, 1902 (*price 3 Rs.*): "Exotic Blocks" of Malla Johar in Bhot Mahals of Kumaon. Pt. 4, 1904 (*price 3 Rs.*): Jammu Coal-fields.
- VOL. XXXIII.** Pt. 1, 1901 (*price 8 Rs.*): Kolar Gold-field. Pt. 2, 1901 (*price 2 Rs.*): Art. 1: Gold-fields of Wainád. Art. 2: Auriferous Quartzites of Parhadiab. Chota Nagpur. Art. 3: Auriferous localities in North Coimbatore. Pt. 3, 1902 (*price 1 Re.*): Geology of Kalahandi State, Central Provinces.
- VOL. XXXIV.** Pt. 1, 1901 (*price 1 Re.*): Peculiar form of altered peridotite in Mysore State. Pt. 2, 1902 (*price 3 Rs.*): Mica deposits of India. Pt. 3, 1903 (*price 1 Re.*): Sandhills of Clifton near Karachi. Pt. 4, 1908 (*price 4 Rs.*): Geology of Persian Gulf and adjoining portions of Persia and Arabia.
- VOL. XXXV.** Pt. 1, 1902 (*price 2 Rs.*): Geology of Western Rajputana. Pt. 2, 1903 (*price 1 Re.*): Aftershocks of Great Earthquake of 12th June 1897. Pt. 3, 1904 (*price 1 Re.*): Seismic phenomena in British India and their connection with its Geology. Pt. 4 (*in the Press*): Geology of Andaman Islands, with references to Nicobars.
- VOL. XXXVI.** Pt. 1, 1904 (*price 4 Re.*): Geology of Spiti. Pt. 2, 1907 (*price 3 Rs.*): Geology of Provinces of Tsang and Ü in Central Tibet. Pt. 3 (*in the Press*): Trias of the Himalayas.
- VOL. XXXVII.** 1909. Manganese-Ore Deposits of India: Pt. 1 (*price 3 Rs.*), Introduction and Mineralogy; Pt. 2 (*price 3 Rs.*), Geology; Pt. 3 (*price 7 Rs.*), Economics and Mining; Pt. 4 (*price 5 Rs.*), Description of Deposits.
- VOL. XXXVIII.** 1910 (*price 5 Rs.*): Kangra Earthquake of 4th April 1905.

PALÆONTOLOGIA INDICA.

(SER. I, III, V, VI, VIII.)—CRETACEOUS FAUNA OF SOUTHERN INDIA, *by*
F. STOLICZKA, *except* Vol. I, Pt. 1, *by* H. F. BLANFORD.

- SER. I & III.—VOL. I. The Cephalopoda (1861-65), pp. 216, pls. 84 (6 double).
V.—VOL. II. The Gastropoda (1867-68), pp. xiii, 500, pls. 28.
VI.—VOL. III. The Pelecypoda (1870-71), pp. xxii, 537, pls. 50.
VIII.—VOL. IV. The Brachiopoda, Ciliopoda, Echinodermata, Corals, etc. (1872-73), pp. v, 202, pls. 29.

(SER. II, XI, XII.)—THE FOSSIL FLORA OF THE GONDWANA SYSTEM, *by*
O. FEISTMANTEL, *except* Vol. I, Pt. 1, *by* T. OLDHAM and J. MORRIS.

- VOL. I, pp. xviii, 233, pls. 72. 1863-79. Pt. 1; Rájmahál Group, Rájmahál Hills, Pt. 2; *The same (continued)*. Pt. 3; Plants from Golapili. Pt. 4; Outliers on the Madras Coast.
VOL. II, pp. xli, 115, pls. 26. 1876-78. Pt. 1; Jurassic Flora of Kach. Pt. 2; Flora of the Jabalpur Group.
VOL. III, pp. xi, 64+149, pls. 80 (9 double) (I—XXXI+IA—XLVIIA). 1879-81. Pt. 1; The Flora of the Talchir-Karharbari beds. Pt. 2; The Flora of the Damuda and Panchet Divisions. Pt. 3; *The same (concluded)*.
VOL. IV, pp. xxvi, 25+66, pls. 35 (2 double) (I—XXI+IA—XIVA). Pt. 1 (1882); Fossil Flora of the South Rewah Gondwana basin. Pt. 2 (1886); Fossil Flora of some of the coal-fields in Western Bengal.

(SER. IX.)—JURASSIC FAUNA OF KACH.

- VOL. I (1873-76). The Cephalopoda, *by* W. WAAGEN, pp. i, 247, pls. 60 (6 double).
VOL. II, pt. 1 (1883). The Echinoidea of Kach, *by* J. W. GREGORY, pp. 12, pls. 2.
VOL. II, pt. 2 (1900). The Corals, *by* J. W. GREGORY, pp. 196, I—IX, pls. 26.
VOL. III, pt. 1 (1900). The Brachiopoda, *by* F. L. KIRCHIN, pp. 87, pls. 15.
VOL. III, pt. 2 (1903). *Lamellibranchiata*: Genus *Trigonia*, *by* F. L. KIRCHIN, pp. 122, pls. 10 (*out of print*).

(SER. IV.)—INDIAN PRE-TERTIARY VERTEBRATA.

- VOL. I, pp. vi, 137, pls. 26. 1365-85. Pt. 1 (1865); the Vertebrate Fossils from the Panchet rocks, *by* T. H. HUXLEY. Pt. 2 (1878); The Vertebrate Fossils of the Kota-Maleri Group, *by* SIR P. DE M. GREY EGBERTON, L. C. MIALL, and W. T. BLANFORD. Pt. 3 (1879); Reptilia and Batrachia, *by* R. LYDEKKER. Pt. 4 (1885); the Labyrinthodont from the Bijori group, *by* R. LYDEKKER (*out of print*). Pt. 5 (1885); The Reptilia and Amphibia of the Maleri and Denwa groups, *by* R. LYDEKKER (*out of print*).

(SER. X.)—INDIAN TERTIARY AND POST-TERTIARY VERTEBRATA, *by*
R. LYDEKKER, *except* Vol. I, Pt. 1, *by* R. B. FOOTE.

- VOL. I, pp. xxx, 300, pls. 50. 1874-80. Pt. 1; Rhinoceros deccanensis. Pt. 2; Molar teeth and other remains of Mammalia. Pt. 3; Crania of Ruminants. Pt. 4; Supplement to Pt. 3. Pt. 5; Siwalik and Narbada Proboscidea.
VOL. II, pp. xv, 363, pls. 45. 1881-84. Pt. 1; Siwalik Rhinocerotidae. Pt. 2; Supplement to Siwalik and Narbada Proboscidea. Pt. 3; Siwalik and Narbada Equidae. Pt. 4; Siwalik Camelopardalidae. Pt. 5; Siwalik Selenodont Suina, etc. Pt. 6; Siwalik and Narbada Carnivora.

VOL. III, pp. xxiv, 264, pls. 38. 1884-86. Pt. 1; Additional Siwalik Perissodactyla and Proboscidea. Pt. 2; Siwalik and Narbada Bunodont Suina. Pt. 3; Rodents and new Ruminants from the Siwaliks. Pt. 4; Siwalik Birds. Pt. 5; Mastodon Teeth from Perim Island. Pt. 6; Siwalik and Narbada Chelonia. Pt. 7; Siwalik Crocodilia, Lacertilia and Ophidia. Pt. 8; Tertiary Fishes.

VOL. IV, pt. 1, 1886. Siwalik Mammalia (Supplement 1); pp. 18, pls. 6.

VOL. IV, pt. 2, 1886. The Fauna of the Karnul caves (and addendum to pt. 1); pp. 40 (19-58), pls. 5 (vii-xi).

VOL. IV, pt. 3, 1887. Eocene Chelonia from the Salt-range; pp. 7 (59-65), pls. 2 (xii-xiii).

(SER. VII, XIV.)—TERTIARY AND UPPER CRETACEOUS FAUNA OF WESTERN INDIA, *by* P. MARTIN DUNCAN and W. PERCY SLADEN, *except* Pt. 1, *by* F. STOLICZKA.

VOL. I, pp. 16+110+382+91=599, pls. 5+28+58+13=104. 1871-85. Pt. 1: Tertiary Crabs from Sind and Kach. Pt. 1 (new 2): Sind Fossil Corals and Alcyonaria; *by* P. Martin Duncan. Pt. 3: The Fossil Echinoidea of Sind: *Fas. 1*, The *Cardita beaumonti* beds; *Fas. 2*, The Ranikot Series in Western Sind; *Fas. 3*, The Khirthar Series; *Fas. 4*, The Nari (Oligocene) Series; *Fas. 5*, the Gaj (Miocene) Series; *Fas. 6*, The Makran (Pliocene) Series; *by* Duncan and Sladen. Pt. 4: The Fossil Echinoidea of Kach and Kattywar, *by* Duncan, Sladen and Blanford.

(SER. XIII.)—SALT-RANGE FOSSILS, *by* WILLIAM WAAGEN, PH.D.

Productus-Limestone Group: Vol. I, pt. 1 (1879). Pisces, Cephalopoda, pp. 72, pls. 6.

" " " " 2 (1880). Gastropoda and supplement to pt. 1, pp. 111 (73-183), pls. 10 (1 double), (vii-xvi).

" " " " 3 (1881). Pelecypoda, pp. 144 (185-328), pls. 8 (xvii-xxiv).

" " " " 4 (1882-85). Brachiopoda, pp. 442 (329-770), pls. 62 (xxv-lxxxvi).

" " " " 5 (1885). Bryozoa-Anelidae-Echinodermata, pp. 64 (771-854), pls. 10 (lxxxvii-xcvi).

" " " " 6 (1886). Coelenterata, pp. 90 (835-924), pls. 20 (xcvii-cxvi).

" " " " 7 (1887). Coelenterata, Protozoa, pp. 74 (925-988), pls. 12 (cxvii-cxxviii).

Fossils from the Ceratite Formation: Vol. II, pt. 1 (1895). Pisces-Ammonoidea, pp. 324, pls. 40.

Geological Results: Vol. IV, pt. 1 (1889), pp. 1-88, pls. 4 (*out of prin.*).

" " " " 2 (1891), pp. 89-242, pls. 8 (*out of print*).

(SER. XV.)—HIMALAYAN FOSSILS.

Upper-triassic and liassic faunæ of the exotic blocks of Malla Johar in the Bhot Mahals of Kumaon: Vol. I, pt. 1 (1908), *by* Dr. C. Diener, pp. 100, pls. 16 (1 double).

Anthracolitic Fossils of Kashmir and Spti: Vol. I, pt. 2 (1899), *by* Dr. C. Diener, pp. 96, pls. 8.

The Permocarboniferous Fauna of Chitichun No. I: Vol. I, pt. 3 (1897) *by* Dr. C. Diener, pp. 105, pls. 13.

The Permian Fossils of the Productus Shales of Kumaon and Garhwal: Vol. I, pt. 4 (1897), *by* Dr. C. Diener, pp. 54, pls. 5.

The Permian Fossils of the Central Himalayas: Vol. 1, pt. 5 (1903), *by* Dr. C. Diener, pp. 204, pls. 10.

The Cephalopoda of the Lower Trias: Vol. II, pt. 1 (1897), *by* Dr. C. Diener, pp. 182, pls. 23.

The Cephalopoda of the Muschelkalk: Vol. II, pt. 2 (1898), *by* Dr. C. Diener, pp. 118, pls. 31.

- Upper Triassic Cephalopoda Fauna of the Himalaya : Vol. III, pt. 1 (1899), by Dr. A. von Mojsisovics, pp. 157, pls. 22.
- Trias Brachiopoda and Lamellibranchiata : Vol. III, pt. 2 (1899), by Alexander Bittner, pp. 76, pls. 12 (2 double).
- The Fauna of the Spiti Shales : Vol. IV, Pt. 1, Fasc. 1 (1903), pp. 132, pls. 18; Fasc. 2 (1910), pp. 133-306, pls. 47 (2 double). By Dr. V. Uhlig.
- The Fauna of the Tropites-Limestone of Byans : Vol. V, Memoir No. 1 (1906), by Dr. C. Diener, pp. 201, pls. 17 (1 double).
- The Fauna of the Himalayan Muschelkalk : Vol. V, Memoir No. 2 (1907), by Dr. C. Diener, pp. 140, pls. 17 (2 double).
- Ladinic, Carnic and Noric fauna of Spiti : Vol. V, Memoir No. 3 (1908), by Dr. C. Diener, pp. 157, pls. 24 (3 double).
- Lower-Triassic Cephalopoda from Spiti, Malla Johar and Byans : Vol. VI, Memoir No. 1 (1909), by Drs. A. von Kraft and C. Diener, pp. 186, pls. 31.
- The Fauna of the Traunatorcinus Limestone of Painkhanda. Vol. VI, Memoir No. 2 (1909), by Dr. C. Diener, pp. 39, pls. 5.
- The Cambrian Fossil of Spiti : Vol. VII, Memoir No. 1 (1910), pp. 70, pls. 6, by F. R. C. Reed.
- The Cretaceous and Silurian fossils from the Central Himalaya : Vol. VII, Memoir No. 2 (*in the Press*), by F. R. C. Reed.

-
- (SER. XVI.)—BALUCHISTAN FOSSILS, by FRITZ NOETTLING, Ph.D., F.G.S.
- The Fauna of the Kellaways of Mazār Drik : Vol. I, pt. 1 (1895), pp. 22, pls. 13.
- The Fauna of the (Neocomian) Belemnite Beds : Vol. I, pt. 2 (1897), pp. 6, pls. 2.
- The Fauna of the Upper Cretaceous (Maëstrichtien) Beds of the Mari Hills : Vol. I, pt. 3 (1897), pp. 79, pls. 23.

(NEW SERIES.)

- The Cambrian Fauna of the Eastern Salt-range : Vol. I, Memoir 1 (1899), K. Redlich, pp. 14, pl. 1.
- Notes on the Morphology of the Pelecypoda : Vol. I, Memoir 2 (1899), Fritz Noetling, pp. 58, pls. 4.
- Fauna of the Miocene Beds of Burma : Vol. I, Memoir 3 (1901), Fritz Noetling, pp. 378, pls. 25 (*out of print*).
- Observations sur quelques Plantes Fossiles des Lower Gondwanas : Vol. II, Memoir 1 (1902), R. Zeiller, pp. 39, pls. 7.
- Permo-Carboniferous (Lower Gondwana) Plants and Vertebrates from Kashmir : (1) Plants, by A. C. Seward; (2) Fishes and Labyrinthodonts, by A. Smith Woodward : Vol. II, Memoir No. 2 (1905), pp. 13, pls. 3.
- The Lower Palaeozoic Fossils of the Northern Shan States, Upper Burma : Vol. II, Memoir No. 3 (1906), by F. R. C. Reed, pp. 154, pls. 8.
- The Fauna of the Napeng Beds or the Rhaetic Beds of Upper Burma : Vol. II, Memoir No. 4 (1908), by Miss M. Healey, pp. 88, pls. 9.
- The Devonian Faunas of the Northern Shan States : Vol. II, Memoir No. 5 (1908), by F. R. C. Reed, pp. 183, pls. 20.
- The Mollusca of the Ranikot Series : Vol. III, Pt. 1, Memoir No. 1 (1908), pp. xix, 83, pls. 8, by M. Cossmann and G. Pissarro. Introduction, by E. W. Vredenburg.
- On some Fish-remains from the Beds at Dongargaon, Central Provinces : Vol. III, Memoir No. 3 (1908), by A. Smith Woodward, pp. 6, pl. 1.
- The Fossil Giraffidae of India : Vol. III, Memoir No. 4 (*in the Press*), by G. E. Pilgrim.

The price fixed for these publications is four annas (4 pence) per single plate, with a minimum charge of Re. 1.

RECORDS OF THE GEOLOGICAL SURVEY OF INDIA.

VOL. I, 1868.

- Part 1 (out of print).*—Annual report for 1867. Coal-seams of Tawa valley. Coal in Garrow Hills. Copper in Bundelkund. Meteorites.
- Part 2 (out of print).*—Coal-seams of neighbourhood of Chanda. Coal near Nagpur. Geological notes on Surat collectorate. Cephalopodous fauna of South Indian cretaceous deposits. Lead in Raipur district. Coal in Eastern Hemisphere. Meteorites.
- Part 3 (out of print).*—Gastropodous fauna of South Indian cretaceous deposits. Notes on route from Poona to Nagpur via Ahmednuggur, Jalna, Loonar, Yeotmalah, Mangali and Hingunghat. Agate-flake in pliocene (?) deposits of Upper Godavary. Boundary of Vindhyan series in Rajputana. Meteorites.

VOL. II, 1869.

- Part 1 (out of print).*—Valley of Poorua river, West Berar. Kuddapah and Kurnool formations. Geological sketch of Shillong plateau. Gold in Singbboom, etc. Wells at Hazareebagh. Meteorites.
- Part 2.*—Annual report for 1868. Pangshura tecta and other species of Chelonia from newer tertiary deposits of Nerbudda valley. Metamorphic rocks of Bengal.
- Part 3.*—Geology of Kuch, Western India. Geology and physical geography of Nicobar Islands.
- Part 4 (out of print).*—Beds containing silicified wood in Eastern Prome, British Burma. Mineralogical statistics of Kumaon division. Coal-field near Chanda. Lead in Raipur district. Meteorites.

VOL. III, 1870.

- Part 1.*—Annual report for 1869. Geology of neighbourhood of Madras. Alluvial deposits of Irrawadi, contrasted with those of Ganges.
- Part 2 (out of print).*—Geology of Gwalior and vicinity. Slates at Chiteli, Kumaon. Lead vein near Chicholi, Raipur district. Wardha river coal-fields, Berar and Central Provinces. Coal at Karba in Bilaspur district.
- Part 3 (out of print).*—Mohpani coal-field. Lead-ore at Slinanabad, Jabalpur district. Coal east of Chhattisgarh between Bilaspur and Ranchi. Petroleum in Burma. Petroleum locality of Sndkal, near Futtijung, west of Kawalpudi. Argentiferous palena and copper in Manbhumi. Assays of iron ores.
- Part 4 (out of print).*—Geology of Mount Tilla, Punjab. Copper deposits of Dalbhum and Singbhum : 1.—Copper mines of Singbhum : 2.—Copper of Dalbhum and Singbhum. Meteorites.

VOL. IV, 1871.

- Part 1.*—Annual report for 1870. Alleged discovery of coal near Gooty, and of indications of coal in Cuddapah district. Mineral statistics of Kumaon division.
- Part 2.*—Axial group in Western Prome. Geological structure of Southern Konkan. Supposed occurrence of native antimony in the Straits Settlements. Deposit in boilers of steam-engines at Raniganj. Plant-bearing sandstones of Godavari valley, on southern extensions of Kamthi group to neighbourhood of Ellore and Rajamandri, and on possible occurrence of coal in same direction.
- Part 3.*—Borings for coal in Godavari valley near Dumagudem and Bhadrachalam. Narbada coal-basin. Geology of Central Provinces. Plant-bearing sandstones of Godavari valley.
- Part 4.*—Ammonite fauna of Kutch. Raigur and Hengir (Gangpur) Coal-field. Sandstones in neighbourhood of first barrier on Godavari, and in country between Godavari and Ellore.

VOL. V, 1872.

- Part 1.*—Annual report for 1871. Relations of rocks near Murree (Mari), Punjab. Mineralogical notes on gneiss of South Mizapur and adjoining country. Sandstones in neighbourhood of first barrier on Godavari, and in country between Godavari and Ellore.
- Part 2.*—Coasts of Baluchistan and Persia from Karachi to head of Persian Gulf, and some of Gulf Islands. Parts of Kummummet and Hanamconda districts in Nizam's Dominions. Geology of Orissa. New coal-field in south-eastern Hyderabad (Deccan) territory.

- Part 3.*—Muskat and Massandim on east coast of Arabia. Example of local jointing. Axial group of Western Promé. Geology of Bombay Presidency.
- Part 4.*—Coal in northern region of Satpura basin. Evidence afforded by raised oyster banks on coasts of India, in estimating amount of elevation indicated thereby. Possible field of coal-measures in Godavari district, Madras Presidency. Lameta or intratrappean formation of Central India. Petroleum localities in Pegu. Supposed eozoneal limestone of Yellam Bile.

VOL. VI, 1873.

- Part 1.*—Annual report for 1872. Geology of North-West Provinces.
- Part 2.*—Bisrampur coal-field. Mineralogical notes on gneiss of south Mirzapur and adjoining country.
- Part 3.*—Celt in ossiferous deposits of Narbada valley (Pliocene of Falconer): on age of deposits, and on associated shells. Barakars (coal-measures) in Beddadanole field, Godavari district. Geology of parts of Upper Punjab. Coal in India. Salt-springs of Pegu.
- Part 4.*—Iron deposits of Chanda (Central Provinces). Barren Islands and Narkondam. Metalliferous resources of British Burma.

VOL. VII, 1874.

- Part 1 (out of print).*—Annual report for 1873. Hill ranges between Indus valley in Ladak and Shah-i-Dula on frontier of Yarkand territory. Iron ores of Kumaon. Raw materials for iron-smelting in Raniganj field. Elastic sandstone, or so-called Itacolymite. Geological notes on part of Northern Hazaribagh.
- Part 2 (out of print).*—Geological notes on route traversed by Yarkand Embassy from Shah-i-Dula to Yarkand and Kashgar. Jade in Karakas valley, Turkistan. Notes from Eastern Himalaya. Petroleum in Assam. Coal in Garo Hills. Copper in Narbada valley. Potash-salt from East India. Geology of neighbourhood of Mari hill station in Punjab.
- Part 3.*—Geological observations made on a visit to Chaderkul, Thian Shan range. Former extension of glaciers within Kangra district. Building and ornamental stones of India. Materials for iron manufacture in Raniganj coal-field. Manganese-ore in Wardha coal-field.
- Part 4 (out of print).*—Auriferous rocks of Dhambal hills, Dharwar district. Antiquity of human race in India. Coal recently discovered in the country of Luni Pathans, south-east corner of Afghanistan. Progress of geological investigation in Godavari district, Madras Presidency. Subsidiary materials for artificial fuel.

VOL. VIII, 1875.

- Part 1.*—Annual report for 1874. The Altum-Artush considered from geological point of view. Evidences of 'ground-ice' in tropical India, during Talchir period. Trials of Raniganj fire-bricks.
- Part 2 (out of print).*—Gold-fields of south-east Wynaad, Madras Presidency. Geological notes on Khareean hills in Upper Punjab. Water-bearing strata of Surat district. Geology of Scindia's territories.
- Part 3 (out of print).*—Shahpur coal-field, with notice of coal explorations in Narbada region. Coal recently found near Mollong, Khasia Hills.
- Part 4 (out of print).*—Geology of Nepal. Raigarh and Hingir coal-fields.

VOL. IX, 1876.

- Part 1 (out of print).*—Annual report for 1875. Geology of Sind.
- Part 2.*—Retirement of Dr. Oldham. Age of some fossil floras in India. Cranium of *Stegodon Ganesa*, with notes on sub-genus and allied forms. Sub-Himalayan series in Jamu (Jammoo) Hills.
- Part 3.*—Fossil floras in India. Geological age of certain groups comprised in Gondwana series of India, and on evidence they afford of distinct zoological and botanical terrestrial regions in ancient epochs. Relations of fossiliferous strata at Maleri and Kota, near Sironcha, C. P. Fossil mammalian fauna of India and Burma.
- Part 4.*—Fossil floras in India. Osteology of *Merycopotamus dissimilis*. Addenda and Corrigenda to paper on tertiary mammalia. *Plesiosaurus* in India. Geology of Pir Panjal and neighbouring districts.

VOL. X, 1877.

- Part 1.*—Annual report for 1876. Geological notes on Great Indian Desert between Sind and Rajputana. Cretaceous genus *Omphalia* near Nameho lake, Tibet, about 75 miles north of Lhasa. *Estheria* in Gondwana formation. Vertebrata from Indian tertiary and secondary rocks. New *Emydine* from the upper tertiaries of Northern Punjab. Observations on under-ground temperature.

RECORDS OF THE GEOLOGICAL SURVEY OF INDIA.

Part 3.]

1910.

[October.

PRELIMINARY NOTE ON A REVISED CLASSIFICATION OF THE TERTIARY FRESHWATER DEPOSITS OF INDIA. BY GUY E. PILGRIM, D.SC., F.G.S., *Geological Survey of India.*

PERHAPS a few words of explanation are needed on the publication of this note, so disproportionately slight as compared with the importance of the conclusions which I seek to establish. Through my omission of the names of localities and of the details of stratigraphical structure, I give little opportunity to another to satisfy himself as to the truth of the facts adduced. My reason for not publishing in complete detail the stratigraphical results so far attained is that I still remain unacquainted with large areas in the north-west of India; and although I feel convinced that the examination of these cannot disprove my conclusions in any important particular, still I am averse from publishing detailed geological descriptions of any part of India, when we are still proceeding with the survey of that part and may reasonably hope to finish it at no distant period. A sufficient argument against delaying it entirely, will, I think, appear in the fact that a concordant classification of the Tertiary freshwater strata of India is essential to enable one to deal satisfactorily with fresh collections of vertebrates, which are coming in year by year from India and the adjacent countries. One attempt in this direction has already been made by the writer, by separating the lower portion of the ossiferous beds of India into two series and assigning to them different

ages. Much as this was needed in Sind and the Bugti Hills, still more is this the case in the Punjab and the Siwalik Hills. For in Sind and the Bugti Hills it had, at all events, been recognised that the fossils there found were the oldest of the "Siwalik group," so called, whereas from north-west India we possess descriptions of considerably over a hundred species of vertebrates, of which all we really know is that they are derived somewhere out of a series of beds some 16,000 to 20,000 feet thick. No reason has been given us for regarding any of these species as more characteristic of one stratigraphical horizon than of another, and if we relied only on the early observations and not on our sense of probability we should expect to find the same species in the top bed as in the bottom. The conflicting character of the species has for long suggested to most palæontologists the extreme improbability of their all being of the same age. So strongly has this been felt, that an admixture of the species has been tacitly assumed; but no fresh facts on the question have accumulated for many years and no table showing the distribution of the various mammalian species exists. This omission it is now my purpose to supply and at the same time to show as far as possible the relation of the various beds to one another.

Even though this is only a preliminary note, still I shall endeavour to state sufficient facts to afford plausible reasons for the classification adopted.

One more point is perhaps worth mentioning. Of the numerous correlations of these beds, which have been suggested by Medlicott, Wynne, Theobald and others, none have been supported by more than the supposed lithological resemblance between the various beds; in no case has one fossil identity been adduced as evidence. Valuable as lithological resemblances may be as confirmatory evidence, much weight must not be attached to them alone in the case of such variable deposits as those produced by rivers. Consequently in what follows the chief stress will be laid on the palæontological evidence, and as the fossils were carefully collected, if not always either by myself or by my assistant Mr. Vinayak Rao personally, yet with an intimate knowledge of the exact locality where they occur, I do not think there are now many species of whose exact horizon we are unaware.

The following is a list of geological maps dealing with different portions of the north-west of India, which have been published

from time to time by the Geological Survey of India. These will render clearer the geographical distribution of the Tertiary deposits referred to in the following pages.

The most comprehensive map, though rather out of date and inaccurate, is Wynne's, in *Rec. Geol. Surv. Ind.*, Vol. X, Pt. 3, p. 109. The following deal with special areas :—

Salt Range: *Mem. Geol. Surv. Ind.*, Vol. XIV.

Kohat and Bannu: *Mem. Geol. Surv. Ind.*, Vols. XVII, Pt. 2, and XI, Pt. 2.

Murree Hills and Kashmir: *Mem. Geol. Surv. Ind.*, Vols. XXII and XXIV, Pt. 2.

Kangra and Siwalik Hills: *Mem. Geol. Surv. Ind.*, Vols. III, Pt. 2, and XXIV, Pt. 2.

Sherani Hills: *Rec. Geol. Surv. Ind.*, Vol. XXVI, p. 77.

Bugti Hills and Dera Ghazi Khan: *Mem. Geol. Surv. Ind.*, Vol. XX, Pt. 2.¹

The Upper Nari.

In a former paper I have shown² that river deposits of Upper Nari (aquitanian) age have been traced through the Bugti Hills to some distance beyond Dera Ghazi Khan. I have now found that these beds are clearly represented over a large part of north-west India. In the Bugti Hills a great unconformity occurs between the Upper Nari beds and the Lower Siwaliks. If we go north to the Kala Chitta Range, running between the Indus river and Rawal Pindi, and to the Murree Hills, we shall have indubitable evidence that here the interval is bridged over by an existing deposit. Here is developed a great mass of strata, from 4,000 to 8,000 feet thick known as the Murree series. Conformably beneath them and resting on the Khirthars are beds of calcareous conglomerate and sandstone and red shale—the Kuldana beds of Wynne³ and Middlemiss.⁴ These

¹ A revised map of part of this area is now in the press and will shortly be published in *Pal. Ind.*, ser. X, Vol. V, pt. 2.

² Tertiary Freshwater Deposits of Baluchistan and Sind. *Rec. Geol. Surv. Ind.*, XXXVII, pp. 145, 146 (1908).

³ Geology of Mari Hill Station, Punjab. *Rec. Geol. Surv. Ind.*, VII, p. 68 (1874).

⁴ Geology of Hazara. *Mem. Geol. Surv. Ind.*, XXVI, p. 42 (1896).

often contain nummulites of Khirthar age, in some places obviously derived, in others giving a deceptive appearance of being *in situ*. They have yielded, particularly in the neighbourhood of Fatehjang, well preserved remains of *Anthracotheerium bugtiense*, *Brachyodus africanus*, *Teleoceras jutehjangense*, a species allied to *T. blanfordi*, and a species of *Hemimeryx*. Two of these species are found in the Nari series of the Bugti Hills and it is impossible to suppose them older than aquitanian. We are therefore able definitely to regard this horizon as Upper Nari. Its conglomerates are unmistakable, and are found overlying the Khirthars throughout the Salt Range as far as the Jhelam river and in the Kohat District across the Indus. In the latter area a ribbed *Unio* occurs in these beds, which may be the same as one of the species found in the Upper Nari of the Bugti Hills. Whether the series exists between the Kohat and Dera Ghazi Khan Districts in the basal beds of what has been mapped as Lower Siwalik, I am uncertain.

The Murree.

The Murree series is developed to its fullest extent in the Murree Hills. In the Rawal Pindi and Jhelam Districts a gradual transition can be traced from typical purple Murree sandstones into typical concretionary conglomerates with a Lower Siwalik fauna. It is possible to trace the gradual dying out of the Murree series as we go south from the Murree and Kala Chitta Hills, until in the Salt Range it is entirely missing, and the 50 to 100 feet of Upper Nari are overlain unconformably by typical Lower Siwaliks.

The Murree series has yielded no vertebrate fossils, but plant remains, including *Sabal major*, occur at Murree and in the parallel beds of the Kasauli series.

The Dagshai and Kasauli series, as has been clearly recognised, entirely correspond to the Murree series. The purple sandstones of this group are unmistakable, from the Siwalik Hills to the Indus. In the Siwalik Hills, however, the Murree series is faulted against the Nahans (Lower Siwalik) and the Nari series has not been recognised. From its relations to the Upper Nari horizon it is clear that the burdigalian and helvetian stages must cover the period of its deposition.

The Lower Siwalik.

In the paper¹ previously quoted I have given a palæontological and lithological description of the Lower Siwalik beds of Sind and the Bugti Hills. I have shown that over that large area the curious concretionary conglomerates form one of their most striking features, while *Dinotherium* and *Tetrabelodon angustidens* are constantly present. I then suggested that a representative of them would be found in the Punjab. This has now proved to be the case. Lithologically as well as palæontologically, a portion of the newer Tertiary formation mapped and described by Wynne, Medlicott, Lydekker, Theobald, Middlemiss, and others, corresponds exactly to the Lower Siwaliks of Sind and Baluchistan. Besides the concretionary conglomerates there are calcareous nodular beds and clays, the whole deeply tinted red, and, by the colouration alone, sharply marked off from the overlying Middle Siwaliks. Real pebbles are entirely absent. The fauna is small; but careful search north of the Salt Range has revealed the presence of *Dinotherium indicum*, and *sindiense*, *Tetrabelodon angustidens*, *Microselenodon silistrensis*, *Merycopotamus pusillus*, *Listriodon pentapotamiae*, and *Hyotherium sindiense*; also a species of *Dryopithecus* allied to *D. rhenanus*, a *Pseudælorus*, and a new Giraffoid genus of a more generalised type than any of those described by Lydekker, to which I have given the name *Giraffokeryx*, and finally representatives of the Creodonta. All these are absent from the overlying beds, from which come the greater number, if not all, of the fossils collected by Theobald in the Potwar. Between Chenji and Kala Kahar in particular these beds contain an abundance of fossils. On Mt. Tilla and on the Bakrara ridge, where they overlie a representative of the Murree series, mammalian remains, though scanty, include the characteristic species *Dinotherium indicum* and *Tetrabelodon angustidens*. *Hipparion* is rare in these beds.

The genus *Dinotherium* has been reported at various places on the right bank of the Indus between Dera Ghazi Khan and Kushalgarh, from beds which are obviously a continuation of the Lower Siwalik outcrop of the Bugti Hills. The horizon at Kushalgarh, referred to in the above mentioned paper² and previously

¹ Pilgrim, *ibid.*, p. 159.

² Pilgrim, *ibid.*, p. 163.

mentioned by Lydekker,¹ is essentially Lower Siwalik, the beds being very similar in character to those of the Bugti Hills. Here the following fossils were obtained :—

Sus hysudricus, Falc. & Caut.

Hyotherium sindiense, Lyd.

Listriodon pentapotamiae, Falc.

Sanitherium schlagintweitii, Meyer.

Merycopotamus pusillus, Lyd.

Dorcatherium majus, Lyd.

Rhinoceros sp.

Hipparion sp.

Dinotherium indicum, Falc. & Caut.

Amphicyon palæindicus, Lyd.

It seems certain, too, that the fossil mammalian fauna of Perim Island must be relegated to the same category, as Lydekker has clearly recognized.

The Nahan series of the Siwalik Hills, and its correlation with the Lower Siwaliks of Sind and the Punjab, is dealt with on page 193 of the present paper.

One word as to the geological age of the Lower Siwaliks. In Europe the range of *Tetrabelodon angustidens* is from burdigalian to sarmatian, which gives us convenient age limits for the series of beds containing this species. We have seen that the Murree series extended in continuous deposit from a horizon in the aquitanian (Upper Nari) right into the Lower Siwalik. It seems hardly reasonable to allow more than the burdigalian and helvetian stages for the accumulation of the Murree sediments. Hence it follows that we should place the base of the Lower Siwaliks no later than tortonian. The fossil evidence lends support to this conclusion, for the alliance between the faunas of the Upper Nari and the Lower Siwalik is not a very remote one.

¹ Fossil Mammalian Fauna of India. *Rec. Geol. Surv. Ind.*, IX, p. 92 (1876). It will be noticed that *Hyaenodon indicus* Lyd. is omitted from this fauna since I have no doubt that the premolar referred by Lydekker to *Hyaenodon* [Pal. Ind. (10) II p. 349] and subsequently by Schlosser [Beitr. Pal. Öst.—Ung VI (1888) p. 195] to *Hyaena* is really the 3rd lower premolar of *Hyotherium sindiense* Lyd. of which numerous specimens occur amongst the rich collections made from the Lower Siwaliks of Chenji. Meyer's *Merycopotamus dissimilis* is I think, *Merycopotamus pusillus*, Lyd. The latter species seems to me to find a more appropriate place in the genus *Hemimeryx*.

The Middle Siwalik.

North of the Salt Range these Lower Siwaliks pass gradually into a richly fossiliferous series of beds, to which I shall restrict the term Middle Siwalik. These beds manifestly thin out as we go eastward to the Jhelam. Lithologically, they are distinguished with ease from the Lower Siwalik, once we are above the passage beds. They are much softer, very much paler in tint, and pebble beds occur here and there. Since, however, the fossils of the Lower Siwaliks, occur near the base of that series and those of the Middle Siwaliks a considerable distance above the passage beds, it is not surprising that the two faunas should be perfectly different. There is actually a vertical distance of some 6,000 feet between these two fossiliferous zones. *Dinotherium* and *Tetrabelodon angustidens* have been replaced by *Mastodon punjabiensis* and *Stegodon*. *Hipparion* and large antelopes abound, and amongst the Giraffoids *Helladotherium* and *Hydaspitherium* have succeeded the more primitive *Giraffokeryx* and *Bramatherium*. The fauna is of a similar type to that of Pikermi and Samos, except in the absence of *Dinotherium*,¹ and a pontian age may undoubtedly be assigned to these beds.

The Upper Siwalik.

An equally gradual transition occurs from the Middle Siwaliks into the still higher beds, seen near Rhotas and at Darapur. These are indistinguishable in character from the strata exposed in the Siwalik Hills, and included by Middlemiss² in his Siwalik conglomerate and Sand-rock stages. They consist of grey sandstones, often very coarse and for the most part exceedingly soft and friable, alternating, especially in their upper portion, with conglomerates and boulder beds. Pink clays occasionally intervene. The Siwalik Hill fauna of the Fauna Antiqua Sivalensis is repeated identically in these beds, though not in such varied abundance. The fauna is quite distinct from that of the Middle Siwaliks and there is remarkably little overlapping of species. The beds form an easily recognisable series and may be known as Upper Siwalik. They can be traced in an almost continuous outcrop, by their lithological character and by

¹ A recent find of two *Dinotherium* teeth supposed to come from the Middle Siwaliks of Nila, north of the Salt Range, suggests that this genus may not have become altogether extinct in India in Middle Siwalik times.

² Geology of Sub-Himalaya of Garhwal and Kumaun. *Mem. Geol. Surv. Ind.*, XXIV (1891).

their fossil contents, from the Salt Range through the Pabbi Hills into Jammu and Kangra and thence into the Siwalik Hills.

Equus, *Bos*, *Elephas*, *Camelus*, and the Giraffoid genus *Sivatherium* characterise this division, these genera being found everywhere in these beds throughout India.

At various localities throughout the Potwar, in the Murree Hills, at Makhad and neighbouring places on the Attock bank of the Indus, near Domeli on the southern side of the Bakrala ridge and at Nammal, north of the Salt Range, we find highly tilted sands and conglomerates resting on the upturned and denuded surface of both Lower and Middle Swaliks. Thus these beds must be newer than the fossiliferous sandstones which succeed the Middle Siwaliks conformably. They are unfortunately almost unfossiliferous, but a metatarsal of *Sivatherium* from the conglomerate near Makhad inclines one to the opinion that all of these beds are probably uppermost Siwalik.

The Upper Siwaliks may be regarded as Pliocene.

Since a thickness of 10,000 feet must be allowed for this part of the series, in its area of maximum development, and since the highest beds at Bubhor contain *Equus namadicus* and *Buffelus palæindicus*, which are Pleistocene forms, it is probable that the series reaches almost, if not quite, to the top of the Pliocene.

Thus, the whole Siwalik series is very conspicuously developed in the Salt Range area and is fossiliferous throughout, in striking contrast to what is the case in the Siwalik Hills. It has been shown above that it is easy to trace the stratigraphical connection between this series and the underlying Murree and Upper Nari series developed either in the same or in adjoining areas. It therefore seems inevitable that we should adopt this as our type area, and correlate the freshwater deposits found in other parts of India with different parts of the Salt Range system, according as we may be guided by fossil or lithological evidence or stratigraphical considerations. I do not intend this to make any alteration in the existing nomenclature, but as from time to time fresh areas are re-mapped or re-examined, the boundaries and names of the formations may, it is hoped, become definite and significant, instead of loose and meaningless as is the case at present.

The Freshwater Deposits of the Siwalik Hills.

My travels in the Siwalik Hills, unfortunately, added but few specimens to my collection and convinced me that there is little

hope in the future of obtaining more. As compensation, however, I was able to visit many of the fossil localities of the old discoverers and have ascertained the important fact that most of them occur near the top of the series, and none of them very far down. The fossils are too fragile to have been carried very far from the beds in which they were deposited and there could have been no collection from talus heaps containing the debris of strata widely different from one another in age. It is, therefore, absolutely certain that the fauna of these beds is considerably newer than the Middle Siwalik fauna and the same strata from which the remains of *Camelus sivalensis* and *C. antiquus* were exhumed, yielded also *Equus*, *Sivatherium*, *Sus*, *Elephas*, *Stegodon*, *Mastodon*, *Chalicotherium*, and *Giraffa*. I am even doubtful whether a single one of the recorded species can be assigned to the same horizon as the Middle Siwaliks of the Punjab, and, failing exact information to the contrary, I prefer, with one exception, to class the whole fauna as Upper Siwalik. This exception relates to the fossils occurring in the very lowest beds bordering the plain, whence, in the Kalawala Rao, Cautley obtained some fossils, of which, whether the others were lost or not, the sole existing remnant, so far as I am aware, are the ones figured in Plate III of Royle's *Himalayan Botany*.¹ Lydekker refers the milk tooth doubtfully to *Anthracotherium (Microselenodon) silistrense*. Cautley found the same bed, a characteristic concretionary clay conglomerate, also on the north side of Nahan and obtained fossils of the same type from it. All trace of these is lost. I, however, re-discovered the bed north of Nahan, though I found no fossils in it. Now I am advancing no new theory, when I refer the Nahan beds to the same horizon as the Lower Siwaliks of Sind,² I would only say that although the lithological resemblance as a whole is not very close, the concretionary clay conglomerate does undoubtedly resemble similar beds from the Lower Siwaliks of the Punjab, while nothing of the sort is known from the Middle Siwaliks. *Anthracotherium (Microselenodon) silistrense* is an ancient type and there seems to be evidence from a specimen formerly in the Rurki museum that a *Dinotherium* tooth was obtained from the base of these hills. Further, the specimen of *Progiraffa sivalensis* which is reported to have come from the hills near Rurki is identical with other specimens obtained

¹ Royle: *Illustrations of the Botany and Other Branches of the Natural History of the Himalayan Mountains*. Introduction, p. xxx (1839).

² *Manual of the Geology of India*, 2nd edition (1893), pp. 357, 364.

from the Lower Siwaliks of Chenji in the Salt Range. For these reasons I would dissent from R. D. Oldham,¹ who places this bed in the so-called "Middle Siwaliks" and considers the occurrence north of Nahan as a "Middle Siwalik" outlier. I think the bed is more appropriately placed with the Lower Siwaliks and considered as forming part of the Nahan series. Mr. Middlemiss has mapped as Nahan, beds which probably occupy a very similar stratigraphical position, to the east of the Ganges.² I am not prepared to dispute Middlemiss' assertion that we have an absolutely conformable series in the Siwalik hills from the Nahan beds upward. I would only suggest, as evidence has shown to be the case elsewhere, that the Middle Siwalik period here was characterised by remarkably slow deposition, so that probably a few hundred feet represents the entire thickness of strata which correspond to the Middle Siwaliks of the Punjab. The lithological character of the whole series in the Siwalik Hills above the Kalawala Rao beds is identical with that of the Upper Siwaliks of the Pabbi Hills, while the vertical thickness of the former set of beds only slightly exceeds that of the latter. This lends additional support to the above view.

Geological History of the Deposits.

In conclusion, I may say that I am on the whole in complete accord with the view expressed by Theobald³ and Middlemiss⁴ as to the general conformability of all these freshwater beds. In fact, speaking broadly, it seems certain that from the Nari to the top of the Siwaliks we have a continuous series of deposits, by which I mean that at no portion of the great period covered by these various deposits was sedimentation altogether interrupted. It is however possible, by correlating the faulting and the thinning out or disappearance of beds in different places, to arrive at the certain conclusion that at six distinct periods earth movements were especially prevalent, and as a result alteration to a greater or less extent took place in the configuration of the land surface, and consequently in the depositing area of the great rivers. These periods of orogenic intensity were as follows:—

1. At the close of Nari times. This is shown by the marine

¹ R. D. Oldham : *Rec. Geol. Surv. Ind.*, XVII, p. 79 (1934).

² Middlemiss : *Geology of Sub-Himalaya of Garhwal and Kumaon. Mem. Geol. Surv. Ind.*, XXIV (1891).

³ Theobald : *Siwalik series. Rec. Geol. Surv. Ind.*, XIV, p. 108 (1881).

⁴ Middlemiss : *Ibid.*, pp. 29, 124 (1891).

transgression which occurred in Sind and deposited the Gaj limestones on the freshwater grits of the Upper Nari. Further north, in the Bugti Hills and the Salt Range, it seems to have checked deposit altogether, because we find the Lower Siwaliks resting on the Nari. Still further north we have sedimentation again and increasing in quantity, until in the Murree series we find freshwater deposits representing not only the Gaj limestones, but also a later period when marine deposition in Sind had ceased. We have therefore in the Rawal Pindi area a continuous river sedimentation corresponding to the continuous series of marine deposits which Vredenburg has shown to exist in Makran from Nari times upward, and which, as the present writer has found, are identically repeated in Persia, extending from aquitanian up to tortonian or sarmatian.

2. The next movements are indicated by the removal of marine conditions in Sind and by the change in the character of the deposit from the Dagshai to the Kasauli series in the sub-Himalayan region.

3. In the tortonian period movements occurred which terminated the great break, which exists from Sind as far as the Salt Range between either Nari or Gaj and Lower Siwalik.

4. At the close of Lower Siwalik times interruption of deposit again occurred, because in the Bugti Hills at all events, and probably in other parts of India as well, the Middle Siwaliks are absent. East of the Jhelam they are probably only feebly represented. On the other hand, between the Jhelam and the Indus, there was a thick deposit of Middle Siwaliks, which passes directly upward into the Upper Siwaliks.

5. It is, however, certain that in many places intense movements followed, and that upheaval and denudation of the Middle Siwaliks occurred, because of the fact that in many places in the Salt Range area (see page 192) highly tilted conglomerates of probably uppermost Siwalik age lie quite unconformably on Middle Siwalik beds.

6. Later than all these disturbances came the last orogenic period which tilted the Upper Siwaliks into the position in which we find them today.

Briefly summarised, the two preceding pages express that at six stages during the deposition of the newer tertiaries of India, earth movements intervened such as to alter the depositing areas of the rivers of that time, producing sedimentation in areas which had

been outside the limits of the deposit, diminishing it in areas where it had been rapid, quickening it in areas where it had been slow, interrupting it altogether; or finally submerging tracts of country and so effecting a replacement of fluvial by marine deposits.

The Upper Tertiaries of Burma.

As far as Burma is concerned, our stratigraphical knowledge of the newer Tertiaries still leaves much to be desired.

It seems certain, however, that from the lowest beds of the Irrawaddy series at Yenangyaung both Noetling and Grimes collected a distinctive vertebrate fauna, which I have examined and in which I have recognised the following species :—

Mastodon latidens, Clift.

Aceratherium lydekkeri, Pilg.

Hipparion punjabiense, Lyd.

Merycopotamus dissimilis, F. & C.

Tetraconodon minor, Pilg.

Hippopotamus iravaticus, F. & C.

Taurotragus latidens, Lyd.

Cervus sp.

To this must no doubt be added *Stegodon clifti* and the fossils obtained by Clift at Yenangyaung and also the *Vishnutherium* mandible collected by W. T. Blanford.

This is a typical Middle Siwalik fauna, that is to say it is older than that of the Siwalik Hills and newer than that of the Lower Siwaliks of Sind, the Bugti Hills and the Salt Range. We may therefore with certainty assign the lowest beds of the Irrawaddy series at Yenangyaung to the Middle Siwalik.

The boundary between these beds and the underlying marine Pegu series is in Upper Burma almost always a well marked one. At Yenangyaung an estuarine zone occurs some 1,200 feet below the base of the Irrawaddy series. From this Dr. Noetling obtained the upper molar of a small Tragulid and the last lower molar of *Dorcatherium* sp., both of them erroneously referred by him to *Anoplotherium*.¹ It is unlikely that these are older than Lower Siwalik. Lately Mr.

¹ Noetling. Fauna of the Miocene Beds of Burma: *Pal Ind.* New series I, p. 378, Pl. XXV, figs. 24, 25.

Cunningham Craig has obtained from Maingyaung in the Pakokku district, which is probably at a horizon only slightly lower than that of Noetling's mammalian teeth, a small lower molar allied to *Telmatodon* which may belong to the same species as an upper molar from the Lower Siwaliks of Sind.¹ Assuming the correctness of the age attributed to these fossils it follows that the Lower Siwalik period in Upper Burma is characterized by marine or estuarine deposits. Moreover, there cannot be any large or widespread unconformity between the top of the Pegu series (Lower Siwalik) and the base of the Irawaddy series (Middle Siwalik).

Mr. Murray Stuart,² however, has lately established the existence in the Prome area in Lower Burma of a marked unconformity in beds hitherto assigned to the Pegu series. He adduces evidence to prove that the beds below the break are of no later than helvetian age.³ The beds above the break (Mogaung sands) are marine passing into estuarine and finally into the fluvial beds of the Irawaddy series. Since the publication of the above paper Mr. Stuart has obtained from these beds an abundance of more than one species of *Ostrea* as well as other mollusca, which occur in the Pegu series in Upper Burma. He is, therefore, inclined to regard the "Mogaung sands" as equivalent to the upper 1,200 feet of the Pegu series at Yenangyaung and so of Lower Siwalik or tortonian age. The absence of distinctive vertebrate fossils both from the Mogaung grits as well as from the Irawaddy beds of this area renders, however, the precise age of the beds succeeding the unconformity very doubtful. The Irawaddy series in Pakokku is, according to Sub-Assistant Sethu Rama Rao, some 8,000 feet thick. No distinctive fossils are known from its upper beds, but, no doubt, they are, in part at any rate, Upper Siwalik. It seems probable that some of the so-called "Plateau gravel" is also Upper Siwalik, since I am informed by Mr. Stuart and Mr. Cunningham Craig that these gravels have often a very considerable dip. From Kyaukwet in the Pakokku district Mr. Lister James has obtained some tooth fragments referable to *Cadurcotherium*, which point to a still lower estuarine zone in the aquitanian.

It only remains now to express in tabular form the subject matter of the preceding pages. This is done in the table on page 205, which will, I hope, render my explanation clearer.

¹ Pilgrim: *Rec. Geol. Surv. Ind.*, XL. pt. 1 p. 68.

² Stuart: *Rec. Geol. Surv. Ind.*, XXXVIII, Pt. 4, p. 266 (1910).

³ Stuart: *ibid.*, p. 274.

On this page and the following will be found a revised list of the Tertiary Mammalia of India, to each species being added the main localities in which it has been found and its geological horizon. I do not think there are many of the species, whose stratigraphical position is open to doubt. It is, however, possible that later discoveries may on the one hand modify our present ideas on the range of certain species and on the other conduce to the separation of forms now classed as one.

Fresh discoveries have necessitated numerous alterations in the nomenclature of genera and species since the latest allusion to them in the publications of the Geological Survey of India. These have, as a rule, been adopted without comment, but I have lately published¹ brief preliminary notes on new species or changes for which I am myself responsible, to which reference can be made if desired.

Tertiary Mammalian Fauna of India.

	Localities.	Nari.	Lower Siwalik.	Middle Siwalik.	Upper Siwalik.
PRIMATES.					
<i>Simia</i> sp. cf. <i>satyrus</i> Linn. .	Siwalik Hills . . .	—	—	—	+
<i>Sivapithecus indicus</i> , Pilgrim	Alipur (Punjab) . . .	—	+	—	—
<i>Anthropopithecus sivalensis</i> , Lyd.	Jabi	—	—	+	—
<i>Dryopithecus punjabicus</i> , Pilg.	Chenji (Salt Range) . . .	—	+	—	—
<i>Semnopithecus palæindicus</i> , Lyd.	Siwalik Hills	—	—	—	+
<i>Semnopithecus asnoti</i> , Pilg.	Asnot	—	—	+	—
<i>Macacus sivalensis</i> , Lyd. . .	Asnot	—	—	+	—
<i>Papio sub-himalayanus</i> , H. Meyer.	Siwalik Hills	—	—	—	+
<i>Papio falconeri</i> , Lyd. . . .	Siwalik Hills	—	—	—	+
CARNIVORA.					
<i>Dissopsalis carnifex</i> , Pilg. .	Chenji and Kotal Kund (Salt Range)	—	+	—	—
<i>Dissopsalis ruber</i> , Pilg. . .	Chenji (Salt Range) . . .	—	+	—	—
<i>Pterodon bugtiensis</i> , Pilg. .	Bugti Hills	+	—	—	—
<i>Pterodon</i> sp., Pilg.	Bugti Hills	+	—	—	—
<i>Hyanarctos palæindicus</i> , Lyd.	Jabi	—	—	+	—

¹ Pilgrim: Notices of New Mammalian Genera and Species from the Tertiaries of India. *Rec. Geol. Surv. Ind.*, XL, Pt. I, p. 63 (1910).

Tertiary Mammalian Fauna of India—*contd.*

	Localities.	Nari.	Lower Siwalik.	Middle Siwalik.	Upper Siwalik.
CARNIVORA—<i>contd.</i>					
<i>Hyænarctos punjabiensis</i> , Lyd.	Asnot	—	—	+	—
<i>Hyænarctos sivalensis</i> , F. & C.	Siwalik Hills	—	—	—	+
<i>Melursus theobaldi</i> , Lyd. .	Kangra	—	—	—	+
<i>Mellivorodon palæindicus</i> , Lyd.	Asnot ; Niki	—	—	+	—
<i>Mellivora punjabiensis</i> , Lyd.	Asnot	—	—	+	—
<i>Mellivora sivalensis</i> , F. & C.	Moginand (Siwalik Hills) .	—	—	—	+
<i>Mustela</i> sp., Lyd.	Siwalik Hills	—	—	—	+
<i>Enhydriodon sivalensis</i> , F. & C.	Siwalik Hills	—	—	—	+
<i>Lutra palæindica</i> , F. & C. .	Siwalik Hills	—	—	—	+
<i>Lutra bathygnathus</i> , Lyd. .	Punjab	—	—	+	—
<i>Amphicyon</i> cf. <i>major</i> , Blainv	Bugti Hills	+	—	—	—
<i>Amphicyon palæindicus</i> , Lyd.	Kushalgarh ; Sind ; Chenji ? Nurpur	—	+	—	—
<i>Amphicyon lydekkeri</i> , Pilg.	Asnot	—	—	+	—
<i>Cephalogale shahbazi</i> , Pilg.	Bugti Hills	+	—	—	—
<i>Canis cautleyi</i> , Bose . . .	Siwalik Hills	—	—	—	+
<i>Vulpes curvipalata</i> , Bose .	Moginand (Siwalik Hills) .	—	—	—	+
<i>Hyæna felina</i> , Bose . . .	Siwalik Hills ; Jamu . . .	—	—	—	+
<i>Hyæna colvini</i> , Lyd. . . .	Siwalik Hills ; Kangra . .	—	—	—	+
<i>Hyæna sivalensis</i> , Bose . .	Siwalik Hills	—	—	—	+
<i>Lyoyæna macrostoma</i> , Lyd.	Jabi ; Dhok Pathán ; Asnot	—	—	+	—
<i>Lepthyæna sivalensis</i> , Lyd.	Asnot ; Dhok Pathán . . .	—	—	+	—
<i>Palhyæna proava</i> , Pilg. . .	Chenji (Salt Range) . . .	—	+	—	—
<i>Palhyæna indica</i> , Pilg. . .	Asnot	—	—	+	—
<i>Palhyæna</i> sp., Pilg. . . .	Asnot	—	—	+	—
<i>Viverra bakeri</i> , Bose . . .	Siwalik Hills	—	—	—	+
<i>Viverra durandi</i> , Lyd. . .	Siwalik Hills	—	—	—	+
<i>Aeluroides sivalensis</i> , Lyd. .	Punjab	—	—	+	—
<i>Aeluroides annectans</i> , Lyd. .	Asnot	—	—	+	—
<i>Machærodus</i> sp., Pilg. . .	Chenji (Salt Range) . . .	—	+	—	—
<i>Machærodus</i> sp., Lyd. . .	Asnot	—	—	+	—
<i>Machærodus sivalensis</i> , F. & C.	Siwalik Hills ; Hoshiarpur .	—	—	—	+
<i>Machærodus palæindicus</i> , Bose.	Siwalik Hills	—	—	—	+
<i>Cynælurus brachygnathus</i> , Lyd.	Siwalik Hills	—	—	—	+
<i>Felis cristata</i> , F. & C. . .	Siwalik Hills	—	—	—	+
<i>Felis subhimalayana</i> , Bronn.	Siwalik Hills	—	—	—	+
<i>Felis</i> sp., Lyd.	Jabi (Punjab)	—	—	+	—
<i>Felis</i> sp. Pilg.	Bhyta (Punjab)	—	—	+	—
RODENTIA.					
<i>Nesokia</i> sp. cf. <i>hardwickii</i> , Gray.	Siwalik Hills	—	—	—	+
<i>Rhizomys sivalensis</i> , Lyd. .	Jabi	—	—	+	—
<i>Rhizomys</i> sp., Lyd. . . .	Siwalik Hills	—	—	—	+

Tertiary Mammalian Fauna of India—*contd.*

	Localities.	Nari.	Lower Siwalik.	Middle Siwalik.	Upper Siwalik.
RODENTIA—<i>contd.</i>					
<i>Hystrix</i> sp., Lyd.	Moginand (Siwalik Hills)	—	—	—	+
<i>Hystrix sivalensis</i> , Lyd.	Asnot	—	—	+	—
<i>Caprolagus sivalensis</i> , Major	Siwalik Hills	—	—	—	+
PROBOSCIDEA.					
<i>Dinotherium indicum</i> , Falc.	Sind ; Bugti Hills ; Kushalgarh ; Dera Ghazi Khan ; Chenji ; Siwalik Hills	—	+	—	—
<i>Dinotherium indicum</i> , Falc. var. <i>naricum</i> , Pilg.	Bugti Hills	+	—	—	—
<i>Dinotherium sindiense</i> , Lyd.	Sind ; Mari (Kohat) ; Chenji	—	+	—	—
<i>Mœritherium</i> (?) sp., Pilg.	Bugti Hills	+	—	—	—
<i>Tetralodon crepusculi</i> , Pilg.	Bugti Hills	+	—	—	—
<i>Tetralodon angustidens</i> , Cuv.	Bugti Hills ; Bakrula Ridge ; Chenji	—	+	—	—
<i>Tetralodon pandionis</i> , Falc.	Asnot ; Niki ; Sind ; Perim I. ; Bugti Hills.	—	+	+	—
<i>Tetralodon falconeri</i> , Lyd.	Sind ; Asnot	—	+	+	—
<i>Mastodon perimensis</i> , F. & C.	Perim I. ; Sind	—	+	—	—
<i>Mastodon cautleyi</i> , Lyd.	Perim I.	—	+	—	—
<i>Mastodon sivalensis</i> , F. & C.	Lehri ; Kangra ; Hoshiarpur ; Siwalik Hills.	—	—	—	+
<i>Mastodon latidens</i> , Clift	Asnot ; Yenangyaung (Burma).	—	—	+	—
<i>Mastodon punjabiensis</i> , Lyd.	Niki ; Asnot ; Dhok Pathan	—	—	+	—
<i>Stegodon clifti</i> , Falc.	Siwalik Hills ; Asnot ; Yenangyaung (Burma).	—	—	+	+
<i>Stegodon bombifrons</i> , F. & C.	Siwalik Hills ; Asnot ; Niki	—	—	+	+
<i>Stegodon ganesa</i> , F. & C.	Lehri ; Hoshiarpur ; Siwalik Hills ; Pabbi Hills	—	—	—	+
<i>Stegodon insignis</i> , F. & C.	Lehri ; Hoshiarpur ; Siwalik Hills.	—	—	—	+
<i>Elephas planifrons</i> , F. & C.	Lehri ; Kangra ; Pinjor ; Siwalik Hills.	—	—	—	+
<i>Elephas hysudricus</i> , F. & C.	Hoshiarpur ; Kangra ; Siwalik Hills ; Pabbi Hills	—	—	—	+
PERISSODACTYLA.					
<i>Cadurotherium indicum</i> , Pilg.	Bugti Hills	+	—	—	—
<i>Aceratherium bugtiense</i> , Pilg.	Bugti Hills	+	—	—	—
<i>Aceratherium lydekkeri</i> , Pilg.	Asnot ; Burma ; Niki ; Jabi	—	—	+	—
<i>Aceratherium perimense</i> , Falc.	Perim I. ; Sind ; Dhariala (Salt Range).	—	+	—	—
<i>Aceratherium gajense</i> , Pilg.	Sind (Gaj series) ; Bugti Hills	+	—	—	—
<i>Aceratherium gajense</i> var. <i>intermedium</i> , Lyd.	Sind	—	+	—	—
<i>Diceratherium shahbazi</i> , Pilg.	Bugti Hills	+	—	—	—

Tertiary Mammalian Fauna of India—*contd.*

	Localities.	Nari.	Lower Siwalik.	Middle Siwalik.	Upper Siwalik.
PERISSODACTYLA—<i>contd.</i>					
<i>Dicera therium naricum</i> , Pilg.	Bugti Hills	+	—	—	—
<i>Teleoceras blanfordi</i> , Lyd. .	Bugti Hills	+	—	—	—
<i>Teleoceras blanfordi</i> , Lyd. var. <i>mihi</i> .	Niki	—	—	+	—
<i>Teleoceras fatehjangense</i> , Pilg.	Ajurwala (Kala Chitta Hills)	+	—	—	—
<i>Dicerorhinus platyrhinus</i> , F. & C.	Siwalik Hills ; Pabbi Hills	—	—	—	+
<i>Rhinoceros sivalensis</i> , F. & C. .	Siwalik Hills ; Asnot ; Dhok Pathán ; Burma	—	—	+	+
<i>Rhinoceros palæindicus</i> , F. & C.	Siwalik Hills ; Asnot ? .	—	—	?	+
<i>Hipparion perimense</i> , Pilg.	Perim I	—	+	—	—
<i>Hipparion feddeni</i> , Lyd. .	Perim I.	—	+	—	—
<i>Hipparion theobaldi</i> , Lyd.	Kaipar ; Niki ; Dhok Pa- thán.	—	—	+	—
<i>Hipparion punjabiense</i> , Lyd.	Niki ; Dhok Pathán . .	—	—	+	—
<i>Hippodactylus antilopinus</i> , F. & C.	Siwalik Hills	—	—	—	+
<i>Hippodactylus ohisholmi</i> , Pilg.	Dhok Pathán	—	—	+	—
<i>Equus sivalensis</i> , F. & C. .	Siwalik Hills ; Rupar ; Lehri ; Pabbi Hills	—	—	—	+
<i>Equus namadicus</i> , F. & C. .	Hoshiarpur ; Kangra .	—	—	—	+
ANCYLOPODA.					
<i>Phyllotillon naricus</i> , Pilg. .	Bugti Hills	+	—	—	—
<i>Schizotherium</i> (?) sp. . . .	Bugti Hills	+	—	—	—
<i>Chalicotherium</i> (?) <i>sindiense</i> , Lyd.	Sind ; Bakrula Ridge ; Chenji	—	+	—	—
<i>Chalicotherium</i> (?) sp.	Tatrot	—	—	+	—
<i>Chalicotherium sivalense</i> , F. & C.	Siwalik Hills	—	—	—	+
ARTIODACTYLA.					
<i>Anthracotherium bugtiense</i> , Pilg.	Bugti Hills ; Ajurwala (Kala Chitta Hills).	+	—	—	—
<i>Anthracotherium</i> (<i>Micro- selenodon</i>) <i>mus</i> , Pilg.	Bugti Hills	+	—	—	—
<i>Anthracotherium</i> (<i>Micro- selenodon</i>) <i>silistrense</i> , Pent.	Sind, Asnot (?) ; Garo Hills ; Chenji ; Siwalik Hills.	—	+	—	—
<i>Ancodus ramsayi</i> , Pilg. .	Bugti Hills	+	—	—	—
<i>Brachyodus hypotamides</i> , Lyd.	Bugti Hills	+	—	—	—
<i>Brachyodus giganteus</i> , Lyd.	Bugti Hills	+	—	—	—

Tertiary Mammalian Fauna of India—*contd.*

	Localities.	Natl.	Lower Siwalik.	Middle Siwalik.	Upper Siwalik.
ARTIODACTYLA—<i>contd.</i>					
<i>Brachyodus africanus</i> , Andr.	Bugti Hills; Ajurwala (Kula Chitta Hills)	+	—	—	—
<i>Merycoops longidentatus</i> , Pilg.	Bugti Hills	+	—	—	—
<i>Hyobooops palasindicus</i> , Lyd.	Sind	—	+	—	—
<i>Hyobooops naricus</i> , Pilg.	Bugti Hills	+	—	—	—
<i>Merycopotamus dissimilis</i> , F. & C.	Asnot; Siwalik Hills; Bhimber.	—	—	+	+
<i>Merycopotamus nanus</i> , F. & C.	Asnot; Siwalik Hills .	—	—	+	+
<i>Hemimeryx speciosus</i> , Pilg.	Bugti Hills	+	—	—	—
<i>Hemimeryx blanfordi</i> , Lyd.	Sind	—	+	—	—
<i>Hemimeryx pusillus</i> , Lyd.	Kushalgarh; Chenji; Perim I; Sind.	—	+	—	—
<i>Telmatodon bugtiensis</i> , Pilg.	Bugti Hills	+	—	—	—
<i>Telmatodon</i> (?) sp., Pilg.	Pakokku (Burma); Sind .	—	+	—	—
<i>Gonotelmia shahbazi</i> , Pilg.	Bugti Hills	+	—	—	—
<i>Chæromeryx silistrensis</i> , Pent.	Garro Hills; Sind . . .	—	+	—	—
<i>Chæromeryx</i> sp. <i>mihi</i> . .	Asnot	—	—	+	—
<i>Tetraconodon magnus</i> , Lyd. non Falc.	Asnot	—	—	+	—
<i>Tetraconodon minor</i> , Pilg.	Yenangyaung (Burma) .	—	—	+	—
<i>Bugtitherium grandincisivum</i> , Pilg.	Bugti Hills	+	—	—	—
<i>Palæochærus affinis</i> , Pilg.	Bugti Hills	+	—	—	—
<i>Palæochærus perimensis</i> , Lyd.	Perim I.	—	+	—	—
<i>Hyotherium sindiense</i> , Lyd.	Sind; Chenji (Salt Range); Kushalgarh.	—	+	—	—
<i>Listriodon pentapotamiæ</i> , Falc.	Kushalgarh; Sind; Niki; Chenji	—	+	?	—
<i>Listriodon theobaldi</i> , Lyd.	Jabi; Chenji	—	+	+	—
<i>Hippohyus sivalensis</i> , F. & C.	Siwalik Hills	—	—	+	+
<i>Hippohyus lydekkeri</i> , Pilg.	Asnot	—	—	+	—
<i>Sus hysudricus</i> , F. & C.	Sind; Kushalgarh; Asnot; Siwalik Hills; Chenji .	—	+	+	+
<i>Sus falconeri</i> , Lyd. . . .	Siwalik Hills	—	—	—	+
<i>Sus punjabiensis</i> , Lyd.	Asnot	—	—	+	—
<i>Santherium schlagintweitii</i> , Meyer.	Kushalgarh	—	+	—	—
<i>Potamochoerus titan</i> , Lyd. .	Asnot; Niki	—	—	+	—
<i>Potamochoerus hysudricus</i> , F. & C.	Siwalik Hills; Asnot .	—	—	+	+
<i>Potamochoerus giganteus</i> , F. & C.	Siwalik Hills	—	—	—	+
<i>Potamochoerus magnus</i> , F. & C.	Siwalik Hills	—	—	—	+
<i>Potamochoerus</i> sp., Lyd. .	Asnot	—	—	+	—
<i>Hippopotamus sivalensis</i> , F. & C.	Siwalik Hills	—	—	—	+

Tertiary Mammalian Fauna of India—*contd.*

	Localities.	Nari.	Lower Siwalik.	Middle Siwalik.	Upper Siwalik.
ARTIODACTYLA—<i>contd.</i>					
<i>Hippopotamus sivalensis</i> , F. & C. var. <i>angustidens</i> , Lyd.	Asnot; Dhok Pathán .	—	—	+	+
<i>Hippopotamus iravaticus</i> , F. & C.	Yenangyaung (Burma); Asnot.	—	—	+	—
<i>Camelus sivalensis</i> , F. & C. .	Siwalik Hills; Hoshiarpur; Rupar; Kangra; Madanpur; Lehri.	—	—	—	+
<i>Camelus antiquus</i> , Lyd. .	Moginand (Siwalik Hills) .	—	—	—	+
<i>Prodremotherium beatrix</i> , Pilg.	Bugti Hills	+	—	—	—
<i>Gelocus naricus</i> , Pilg. .	Bugti Hills	+	—	—	—
<i>Dorcabune anthracotheroides</i> , Pilg.	Chenji and Kotal Kund (Salt Range); Sind.	—	+	—	—
<i>Dorcatherium birmanicum</i> , Noetting.	Yenangyaung (Burma, Pegu series).	—	+	—	—
<i>Dorcatherium majus</i> , Lyd. .	Kushalgarh; Sind; Chenji (Salt Range); Asnot.	—	+	+	—
<i>Dorcatherium minus</i> , Lyd.	Pohta; Asnot; Chenji .	—	+	+	—
<i>Tragulus sivalensis</i> , Lyd. .	Asnot	—	—	+	—
<i>Progiraffa exigua</i> , Pilg. .	Bugti Hills	+	—	—	—
<i>Progiraffa sp.</i> , Pilg. . .	Sind	—	+	—	—
<i>Progiraffa sivalensis</i> , Lyd. .	Siwalik Hills; Chenji (Salt Range).	—	+	—	—
<i>Giraffa sp.</i> , Falc. . . .	Perim I.; Chenji (Salt Range).	—	+	—	—
<i>Giraffa punjabiensis</i> , Pilg. .	Asnot	—	—	+	—
<i>Giraffa sivalensis</i> , F. & C. .	Siwalik Hills	—	—	—	+
<i>Vishnutherium iravaticum</i> , Lyd.	Burma; Asnot	—	—	+	—
<i>Giraffokeryx punjabiensis</i> , Pilg.	Chenji and Phadial (Salt Range)	—	+	—	—
<i>Helladotherium grande</i> , Lyd.	Asnot; Dhok Pathán .	—	—	+	—
<i>Indraderium majori</i> , Pilg.	Markanda (Siwalik Hills)	—	—	—	+
<i>Bramatherium perimense</i> , Falc.	Perim I.	—	+	—	—
<i>Hydaspherium magnum</i> , Pilg.	Asnot	—	—	+	—
<i>Hydaspherium megacophalum</i> , Lyd.	Asnot; Niki	—	—	+	—
<i>Hydaspherium birmanicum</i> , Pilg.	Singu (Burma)	—	—	+	—
<i>Sivatherium giganteum</i> , F. & C.	Siwalik Hills; Kangra; Pabbi Hills; Makhad.	—	—	—	+
<i>Moschus sp.</i> , Lyd. . . .	Punjab	—	—	+	—
<i>Cervus sivalensis</i> , Lyd. .	Siwalik Hills; Tatrot .	—	—	—	+
<i>Cervus simplicidens</i> , Lyd. .	Asnot; Dhok Pathán .	—	—	+	—
<i>Cervus triplidens</i> , Lyd. .	Punjab	—	—	+	—
<i>Bubalus palaeindicus</i> , Falc. .	Siwalik Hills	—	—	—	+

Tertiary Mammalian Fauna of India—concl'd.

	Localities.	Nari.	Lower Siwalik.	Middle Siwalik.	Upper Siwalik.
ARTIODACTYLA—cont'd.					
<i>Tetraceros daviesi</i> , Lyd. .	Siwalik Hills	—	—	—	+
<i>Cobus patulicornis</i> , Lyd. .	Siwalik Hills ; Hoshiarpur . .	—	—	—	+
<i>Cobus palæindicus</i> , Lyd. .	Siwalik Hills	—	—	—	+
<i>Cobus gyricornis</i> , Falc. .	Siwalik Hills	—	—	—	+
<i>Gazella porrecticornis</i> , Lyd. .	Asnot	—	—	+	—
<i>Hippotragus sivalensis</i> , Lyd. .	Siwalik Hills ; Kangra . .	—	—	—	+
<i>Boselaphus lydekkeri</i> , Pilg. .	Asnot	—	—	+	—
<i>Boselaphus</i> sp. cf. <i>namadicus</i> , Rüt. .	Siwalik Hills ; Kangra . .	—	—	—	+
<i>Strepsiceros</i> (?) <i>falconeri</i> , Lyd. .	Perim I.	—	+	—	—
<i>Taurotragus latidens</i> , Lyd. .	Asnot ; Yenangyaung (Burma) ; Nila. . . .	—	—	+	—
<i>Tragoceros perimensis</i> , Lyd. .	Perim I.	—	+	—	—
<i>Tragoceros punjabicus</i> , Pilg. .	Dhok Pathán ; Asnot . .	—	—	+	—
<i>Hemitragus sivalensis</i> , Lyd. .	Siwalik Hills	—	—	—	+
<i>Bucapra daviesi</i> , Rüt. .	Siwalik Hills	—	—	—	+
<i>Anoa</i> sp., Pilg.	Asnot	—	—	+	—
<i>Anoa triquetricornis</i> , Rüt. .	Siwalik Hills	—	—	—	+
<i>Anoa antilopinus</i> , F. & C. .	Ganawa Khal (Siwalik Hills) ; Kangra. . . .	—	—	—	+
<i>Amphibos acuticornis</i> , Rüt. .	Siwalik Hills	—	—	—	+
<i>Buffelus palæindicus</i> , Falc. .	Bubhor ; Jamu	—	—	—	+
<i>Buffelus platyceros</i> , Lyd. .	Sutor (Kangra) ; Pabbi Hills.	—	—	—	+
<i>Leptobos falconeri</i> , Rüt. .	Siwalik Hills	—	—	—	+
<i>Bison sivalensis</i> , Lyd. .	Pinjor (Siwalik Hills) . .	—	—	—	+
<i>Bos acutifrons</i> , Lyd. . .	Kangra	—	—	—	+
<i>Bos planifrons</i> , Lyd. . .	Kangra	—	—	—	+
<i>Bos platyrhinus</i> , Lyd. .	Kangra ; Umb	—	—	—	+

PART 3.]

Europe.	Persia and Makran.	Kangra.	Siwalik Hills.	Burma.
Pliocene .	Fluviatile deposits of Siw and Bakhtiyari series. (Horizon uncertain)	<i>Equus siwalensis</i> ; <i>Equus giganteus</i> ; <i>Equus</i> ; <i>Buffalus</i> sp. various.	Upper Siwaliks <i>Camelus siwalensis</i> ; <i>Equus siwalensis</i> ; <i>Sivatherium giganteum</i> ; <i>Elephas hyndricus</i> ; <i>Potamochoerus giganteus</i> ; <i>Hippodactylus andilopinus</i> . <i>Bos</i> . sp. various.	Fluviatile deposits of upper portion of the Irraddy series; tilt "Plateau gravels" (horizon uncertain).
Pontian .		<i>Megacephalus</i>	Deposition scanty	Lowest beds of the Irraddy series. (Middle Siwaliks) <i>Mastodon latidens</i> ; <i>Hipparion punjabense</i> ; <i>Tetraodon min</i> <i>Taurotragus latidens</i> .
Sarmatian .				
			Nahan series (Lower Siwaliks) <i>Microselenodon siliatensis</i> ; <i>Dinotherium indicum</i> ; <i>Prograffa sicalensis</i> .	Pegu series Marine conditions downwards at least to Stampian. Iguanodon beds with <i>Dorotherium birmanicum</i> 1,2 feet below the top. Local unconformities at more than one horizon.
Tortonian .	Continuous series of mud beds from Stampian onwards to an unconformity which is at the Tortonian in Northern Persia and Southern Persia later.	<i>Dinotherium</i>		
Helvetian .				
Burdigalian	Zone of <i>Ostrea latimargina</i> Vred.		Dagshai series	Zone of <i>Ostrea latimargina</i> Vred.
Aquitauian		present or if	Upper Nari Apparently absent or if present marine.	Estuarine beds Zone of <i>Cadurcotherium indicum</i> .
Stampian .		present.	Lower Nari Apparently absent.	

A REVISION OF THE SILURIAN-TRIAS SEQUENCE IN KASHMIR. BY C. S. MIDDLEMISS, B.A., F.G.S., *Superintendent, Geological Survey of India.* (With Plates 28 to 39.)

TABLE OF CONTENTS.

	PAGE.
INTRODUCTION	206
GENERAL OUTLINE OF THE STRATIGRAPHICAL SEQUENCE	209
DIVISION A—BELOW THE VOLCANIC SERIES—	
I.—Older Silurian and ? Cambrian	211
II.—Upper Silurian	213
III.—“Muth” Quartzite	216
IV.—Syringothyris Limestone Series (L. Carboniferous)	217
V.—Passage Beds	222
VI.—Fenestella Series (M. Carboniferous ?)	222
PANJAL VOLCANIC FLOWS AND AGGLOMERATIC SLATE	232
DIVISION B—ABOVE THE VOLCANIC SERIES—	
VII.—Gangamopteris Beds (L. Gondwanas)	236
VIII.—Zéwan or Permo-Carboniferous	237
IX.—Trias	240

INTRODUCTION.

SINCE the year 1883, when the first and only general account of the geology of Kashmir appeared (*Mem. Geol. Surv. India*, Vol. XXII), much detailed stratigraphical and palæontological work has

Some imperfections in the original survey of Kashmir.

been accomplished in other Himalayan areas, notably Kumaun and Spiti, with the result that an extensive belt of very richly fossiliferous sedimentaries in those regions has been fully explored and correlated more or less completely with standard European horizons.¹

¹ The list of papers and monographs dealing with this subject is too lengthy to quote here, but in particular one may refer to the works of Griesbach, Hayden, von Krafft and Diener, in the Records and Memoirs of the Geological Survey of India, and in the *Palæontologia Indica* (see list of references at the end of this paper).

Until recently no opportunity occurred of testing the old Kashmir sequence by the light of these later surveys, and when such did occur it resulted in a few short and spasmodic visits only. These, nevertheless, were characterised by new and striking discoveries that pointed to some serious deficiencies and not a few mistakes in the original general description referred to above.¹

If one takes into account the size of Kashmir and the adjacent territories treated of in Lydekker's memoir and map, if one also remembers the rugged, mountainous, and often inhospitable nature of the surface in the more out-of-the-way parts, and finally if one bears in mind the cardinal fact that geology is always progressive, one is not so much struck perhaps by the circumstance that revision has been found necessary over some parts of the area, as by the fact that Lydekker accomplished as much as he did. In such a complex field, those who follow after the original pioneer, fitted out with later knowledge and more complete records of adjacent regions, must of necessity come upon new discoveries and detect certain errors, great or small as the case may be. If, therefore, in this paper I seem to indulge in much detailed criticism traversing Lydekker's early work, I wish it simply to be understood that this arises from the nature of the case, and is in no sense remarkable.

As a case in point, in a recent paper in these *Records* (Vol. XXXVII, pt. 4, pp. 319—327), the result of a few months' visit to Kashmir in 1908, I drew attention by means of, and in consequence

A new interpretation of the Lidar valley sequence.

of, some sections near Eishmakám, Dowhat (Duwhat) and Lur (Lir) to an interpretation of the structural folds and stratigraphical sequence in the Lidar valley that differed materially from the one adopted by Lydekker (*loc. cit.* pp. 136—138, 227). Instead of there being a number of isoclinal folds of Permo-Carboniferous and Trias rocks (Kuling and Supra-Kuling of Lydekker) repeated among an older system of Panjal traps, slates and quartzites, then believed to be of Silurian and Cambrian age, I provisionally hazarded the opinion that the whole of this seeming complex was merely a regularly ascending series from beds of Lower Carboniferous age exposed at Eishmakám up to the Permo-Carboniferous and Trias of Pailgam (Palgam), taking in on the way in ordinary sequence the so-called Panjal quartzites and

¹ References to the published accounts of these will also be found at the end of this paper.

slates with the supposed Kuling isoclines, the agglomerates, and the Panjal volcanic flows—which last by this interpretation become of about Upper Carboniferous age.

During last summer (1909) I had the pleasure of revisiting the area, and was able to establish fully by further detailed study the provisional conclusions given above. As a result, the stratigraphical sequence at the above localities now becomes as follows in descending order:—

- (f) Permo-Carboniferous and Trias of Pailgam.
- (e) Panjal volcanic flows, (? Upper Carboniferous), between Virsiren and Genesbal.
- (d) Agglomeratic Slate Series, of the neighbourhood of Bhatkot, etc.
- (c) Fenestella Series (? Middle Carboniferous), Black shales and Quartzites of east bank of Lidar valley, south-south-east of Dowhat and Lur.
- (b) Passage Beds.
- (a) Syringothyris Limestone Series, (Lower Carboniferous) of Eishmakám Hill.

This order is also the surface order of outcrop of the beds from Pailgam down to Eishmakám, so that with an apparently steady N. E. dip throughout, there is no need to invoke any complicated folds to explain the present lie of the beds. Confirmation of this was also afforded during last season's work by my tracing to the S. W. of Eishmakám as far as the main opening of the valley S. E. of Shari Bal Station, exactly the same sequence but in reversed order and with opposite dips, a condition which naturally implies the complementary half of one grand anticlinal arch in a normal ascending series of formations.

As it is of some importance to appreciate exactly this initial point of

Illustrative sections.

divergence between Lydekker's interpretation of the Lidar valley sequence and mine, I reproduce the former's original diagrammatic section from Pailgam to Islamabad as given in his memoir, and with it for comparison I give my own section through nearly the same area (see Pl. 29, figs. 1 and 2). It is necessary to say, however, that some of the differences observable between the two interpretations are due to the line of section being not quite the same. This is, however, only a matter of detail: for the moment the two views thus illustrated may be regarded as a brief statement or opening

of the case. I would specially draw attention to the part of each section marked A—B, which is the *crux* of the whole matter. On the other hand, the inversion or no inversion, as shown at the south-west end of the two sections, is merely a matter of the exact course of that part of the section, which at one place is much as Lydekker has drawn it, and in another as drawn by me.

From the examination of this question I was gradually led further afield studying neighbouring and related areas, until the accumulated data practically took the form of a resurvey of the portion of Kashmir illustrated in Plate 39. Instead, therefore, of stopping now to enlarge on and give detailed proofs for my particular interpretation of the Lidar sequence (inasmuch as its elaboration is only a single, though important, incident among many new results attained here both as regards structure, stratigraphy, and the defining of several exact fossil horizons), it will be well to re-describe afresh the whole area comprised within the accompanying map. In this way an orderly account of the complete stratigraphical record from Silurian to Trias will be secured, with the above and other long-standing errors and omissions rectified, and much fresh matter of interest introduced.

I have to thank the Kashmir Darbar for permitting me again to work and collect in the State, and for all the facilities accorded me in carrying out my explorations. I must also acknowledge with pleasure the great assistance in collecting rendered me by student Lala Joti Parshad, B.A., who was receiving field-training at my hands. By means of his intelligent co-operation I was able quite to double the amount of paleontological material that I should otherwise have amassed.

General outline of the stratigraphical sequence.

It will conduce to clearness if for the moment we assume my conclusions, and for descriptive purposes adopt a division of the stratigraphical record embraced in this note into two principal portions, namely, the one below and the one above the great Panjal volcanic series. On that assumption, considering the enormous difference the accumulation of about 10,000 feet of these lavas and agglomerates has made to that sequence, and to the surface results of the mountain area now sculptured out of them, the convenience of such a division becomes obvious. For these volcanic accumulations thereby represent an interval of time, however

great or small it may actually have been, during which events of a revolutionary character moved quickly, and the whole order of things became changed; when peaceful marine sedimentation gave place to volcanic outbursts on so grand a scale that there is but little doubt that great accompanying changes of level and of land and sea areas must have occurred, not only as a consequence of this enormous extravasation of molten magma, but also as a preliminary to it. This is hinted at, as we shall see, by an unconformity below the volcanic series and by the land areas that followed those volcanics bearing a Gondwana flora¹; whilst the close of this revolutionary period is finally marked by the re-establishment of the Tethys sea and the return again to ordinary marine conditions during Permo-Carboniferous and Trias times.

Furthermore, if the Talchir age, provisionally ascribed to the lower of the Gondwana plant horizons in the Golabgarh pass is correct, the revolutionary nature of the preceding period is accentuated when we recall the fact that widespread glacial conditions then obtained over the continents of India, South Africa, Australia, etc.

The following outline table will now indicate the main sub-divisions in descending order, as determined by my survey :—

DIVISION B.

(Above the Panjal Volcanics.)

11. Upper Trias.
10. Muschelkalk.
9. Lower Trias.
8. Zéwan or Permo-Carboniferous.
7. Gangamopteris Beds (Lower Gondwanas).

PANJAL VOLCANIC FLOWS.

AGGLOMERATIC SLATE.

DIVISION A.

(Below the Panjal Volcanics.)

6. Fenestella Series (? Middle Carboniferous).
5. Passage Beds.
4. Syringothyris Limestone Series (Lower Carboniferous).
3. "Muth" Quartzite.
2. Upper Silurian.
1. Lower Silurian and (?) Cambrian.

¹ *Rec. Geol. Surv. Ind.*, Vol. XXXVII, pt. 4, p. 298.

DIVISION A.—BELOW THE VOLCANIC SERIES.

I.—Older Silurian and ? Cambrian.

The lowest horizon which can be maintained with some probability by characteristic fossil evidence is the Upper Silurian, shown on the map as a narrow deep-tinted band bordering all the still older sedimentaries which are here referred to as Older Silurian and ? Cambrian.

The exact age of these latter is very speculative. Fossils are not entirely wanting in them, but as far as I have found them they are quite indeter-

Obscure fossils.

minable, partly because most of them are mere vague outlines or ferruginous smudges and partly because they no longer are aggregated into a well-marked continuous horizon but appear here and there at random—shades or ghosts of fossils that are more numerous and less ill-preserved in the layers near to the Upper Silurian horizon, whilst away at some depth below this their identity as organic remains would not be admitted by anyone who had not followed the process of their gradual effacement step by step from the higher, better preserved, layers. These chance layers of rusty spots and blotches, with occasional shell structure preserved, are all the evidence I can produce that older Silurian and possibly Cambrian are represented. The argument is summed up by saying that they may be traced lying at many hundreds of feet below the Upper Silurian, and as they indubitably are fossil traces, they must be older than Upper Silurian and may be Cambrian. It is not impossible that some future explorer may be successful in finding what I have failed to do, namely, some better-preserved traces of the fauna of these lowermost rocks.

The surface area where these older rocks are found is of considerable

Distribution.

extent in the portion of Kashmir here described, but there can be no doubt that further S. E. still larger areas are similarly composed. Three main valleys running N. E.—S. W. will be seen from the map to section this main area. They are (1) the Gugaldar-Harpatnar Valley, which joins the Lidar very low down in its course, (2) the valley of the Arpat river descending from Hairbal gali (pass), and (3), the Naubug valley descending from the Margan pass. Beyond the latter another tract of these strata is shown deeply cut through by the Maru Wardwan (river) where the beds become gradually metamorphosed by the intrusion of

the ordinary Himalayan gneissose granite (see sections, Pl. 30, figs. 1 and 2).

In composition these older Silurian or Cambrian strata are very uniform and characteristic. The predominant feature in them is their thin-bedded, argillaceous and siliceous nature, and their dull pale drab colours, which only here and there become varied shades of purple, blue-grey and pale greenish white. A considerable sandy element, often micaceous, is frequently intermixed with the argillaceous, but sparingly so as never to give a massive or quartzitic aspect to the hill outcrops. There are also some calcareous layers in the upper parts, sometimes white and crystalline, sometimes reddish brown in colour. Near Gugaldar, and between Dardpura and Hairbal (especially in the latter place) as well as at Gauran (Guran) under the Margán pass these limestones attain some thickness. Not a trace of fossils was found in them though they possibly represent the Silurian limestones of Spiti. The mixed, thin-bedded material thus resulting may be generally described as slaty shales, sandy micaceous shales, or fine compacted earthy sandstones, siliceous shales and a few much altered limestones. No good cleavage has influenced them, but an imperfect cleavage is almost universal, whilst in places shearing and cleavage have together brought about a "gnarled" aspect. A phyllitic condition prevails in many places, whilst in the Wardwan valley schistosity becomes more prevalent as a result of the metamorphic action of acid plutonic masses. Like their contemporaries over many parts of the world such rocks might be referred to as greywacke. They give to the country-side soft rounded outlines as a result of the crumbling that inevitably affects soft, but tough, strata of their composition; and they thus have afforded easy progress for the glaciers that in pre-recent times filled these valleys, and whose moraines have still occasionally been preserved. Outcrops of rock can hardly be traced at all on the N. W. slopes of the hills where soil and forest prevail, but the sunny S. E. faces usually afford sufficiently continuous sections.

The great mass of these greywacke beds, as seen in the main western area, arch over in the form of a great anticlinal fold about a N. E.—S. W. axis, extending from the neighbourhood of Shamahal springs to Gauran in the Naubug valley, and beyond. The angles of dip on the north-east side of the fold under the high watershed and over most of

the area are rather steep, from 40° to 60° , but on the south-west side of the fold in the Arpat river towards Paisan there is slight inversion of the greywackes and succeeding strata, whilst at Gudramer (Gudaman) the same are nearly vertical. The axis of the anticlinal pitches towards the N. W., but the bending round of the strike which follows on this is obscured by the wide stretches of recent gravels of the Lidar valley. At the Margán pass these older palaeozoic slates follow under the younger strata forming with them a synclinal trough having steep, practically vertical dips at Lutherwan where the greywackes reappear and continue down into the Wardwan valley. The structural folds in the latter valley could not be followed out. The phyllitic, sheared and incipient augen structures that become so prevalent in the Inshin (Wardwan) representatives of this system indicate much intimate destruction of original structural planes in this valley, as a preliminary to a final schistosity along new lines wherever the gneissose granite bands are approached.

II.—Upper Silurian.

The identification of relatively well-preserved fossils in the 100 feet or so of strata coming immediately above the system last described, and at several distinct localities, introduces the first new feature in the stratigraphy of Kashmir, inasmuch as Lydekker declared the whole of his Panjal system (which he relegated to the Silurian and Cambrian) to be "totally devoid of organic remains with the possible exception of some obscure impressions from one locality which might be graptolites" (*loc. cit.*, p. 212). Beds of this age, with a characteristic fauna, are now well known to occur in Spiti, Kumaun and Burma, but to the west in Hazara, the Salt Range, and other districts near the North-Western Frontier they have not yet been discovered, though they are known from Afghanistan.

The following is a list of the places where I have collected Upper Silurian remains in Kashmir :—

- (1)—Several points between Wajru and Hairbal Gali, including Gugaldar, where many specimens were gathered.
- (2)—Just S. W. of Gudramer (Gudaman) in the Naubug valley. This also is a rich locality.
- (3)—Below the Margán Pass on the S. W. side.

- (4)—At Lutherwan on the north-east side of the Margán Pass.
A fairly rich locality.

It is however almost certain that an exhaustive search all round the dotted line as drawn on the map would reveal many more equally good places. The principal localities above enumerated may be shortly described in view of the interest attaching to them.

(1) *Gugaldar*—lat. $33^{\circ} 51'$, long. $75^{\circ} 25'$.—This village lies high up towards the head of the Harpatnar valley at the junction of two side streams. Much of the cultivated area of this hamlet lies on the spit of moraine and gravel-covered easy sloping land between the junction of these two streams. Immediately west of the village on the rocky (west) side of the right side-stream there descends a well-outlined spur from the superposed massive quartzite crags, with more thinly bedded siliceous shales below, and at the very base near the stream bed the 100 feet or so of blue-grey, rusty weathering, sandy shales, occasionally calcareous, and reasonably full of casts and impressions of *Orthis*, etc., coated yellow with limonite—(1) 19-6-09.¹ From this point the strike carries it E. by S. under the fields referred to above, and then along the slopes on the north side of the left side-stream. In the other direction it winds round several spurs on its way across the ridge to near Wajru.

My collection was wholly made from the foot of the spur first mentioned, where a zigzag pathway winds up it. The rock is easy to find, here and at all other localities, if it be borne in mind that it is the topmost of the thin-bedded greywacke coming below the more siliceous shales and finally quartzites of the towering crags above (see section Pl. 30, fig. 1).

A provisional description of the fauna will follow the description of the other localities, as all are practically identical in their fossil content.

(2) *Gudramer* (*Gudaman of Atlas Sheet*)—lat. $33^{\circ} 41'$, long. $75^{\circ} 27'$.—This locality is situated in the high and pleasant valley of Naubug. The beds outcrop nearly vertically from a gap in the ridge to the N. N. W. down to a spur descending to the river-bed at a point $\frac{1}{4}$ mile S. W. and S. of the village. As before, its position can be found by its propinquity to the massive quartzite which follows to the S. W. The rock, though somewhat more calcareous in places, is generally precisely like that at Gugaldar, both petrologically and as regards fossil contents—(1) 11-7-09. It is rudely cleaved (see Pl. 30, fig. 2).

¹ This and similar numbers indicate horizons as shown in the table, sections and sketches.

(3) *Under Margán Pass S. W. side*—lat. $33^{\circ} 44'$, long. $75^{\circ} 32'$.—This is an elevated spot on the talus-covered slopes, after the main ascent to the pass has begun and a well defined steep little moraine has been ascended. It bears N. W. from the Shilsar Pass, where the continuation of the band can be seen to go. The rocky crags (again below the quartzite) are much broken in outcrop, and collecting is difficult. A few specimens however were obtained, both when I ascended and descended the pass—(1) 21-7-09 (see Pl. 30, fig. 2).

(4) *Lutherwan (camp)*—lat. $33^{\circ} 46'$, long. $75^{\circ} 35'$.—This locality is among the gently rolling, flower-strewn "margs," before the main descent to Wardwan begins, at some 3 or 4 miles from the actual pass and just at the tree limit. There is no village, the place being only a summer grazing centre for flocks and herds. The fossiliferous band (1) 22-7-09, occurs in scattered small crags, jutting out from the slopes, opposite Lutherwan, and S. W. of the side-stream coming from N. N. W. to join the main stream near the bridge below Lutherwan. The direct path from Wardwan to the pass (not stopping at Lutherwan) goes directly across the beds, keeping to the further (left) bank of the main stream. The crags can be seen to outcrop up the higher slopes to the high ridge to the N. W., where possibly a more perfect section would be got. I did not visit the ridge.

The rock is of the usual kind, with a few subordinate brownish yellow calcareous bands. Its position, as regards the lower and upper series with which it is in sequence, is the same as described in the localities before (see Pl. 30, fig. 2).

Petrology.

It may generally be remarked here that a great proportion of the fossil-bearing formations that will presently be described have a very similar composition to that given above. That is to say they consist of a tough sandy shale or shaley sandstone, dark in colour, fine in grain and here and there hardened into lumpy pieces by a small proportion of calcareous matter. The latter (whether residual, and representing what was once a rock of a much more calcareous nature, or not) may here and there become a limestone. In fact the rock seems to change laterally from place to place. During these lateral changes it keeps much the same external appearance. It resists weathering and pressure, and also yields to them, in a minor degree. I am inclined to think that the preservation of occasional fossil layers in them is due to a combination of resistance and yielding to crushing

which a tough rock of this kind can do, followed by differential weathering at and near the surface.

Throughout all these exposures the most common fossil forms represented belong to the family *Orthidæ*.
Fauna. These in fact make up more than 90 per cent. of the whole fauna, and probably include several genera and species. I have not, however, ventured to determine them more definitely; although not a few closely resemble specimens figured by Salter and Blanford (*Palæontology of Niti*) and by F. R. Cowper Reed from Burma (*Pal. Ind.*, New Series, Vol. 2, No. 3). A few *Strophomenæ* are represented, a small *Spirifer*, corals, among which *Petraia* or *Lindstrœmia* is recognisable, and a fair proportion of small *trilobite* fragments most of which belong to the genera *Calymene*, although *Eucrinurus?* and *Acidaspis?* are also represented. One specimen of a *bryozoon* and one large *Orthoceras* complete the list as so far determined.

There can be no doubt about the Lower Palæozoic character of this small fauna, whilst the probably Upper
Age. Silurian age is rendered stronger by the position of the beds being immediately at the base of what is believed to be the Muth quartzite of Spiti. Without the latter piece of evidence, the correlation of these beds with the Upper Silurian would be somewhat doubtful, as many characteristic forms such as *Heliolites*, *Favosites* and *Halysites catenularia*, Linn., that signalise the Spiti area are as yet unknown from Kashmir. The beds and also those below are generally less calcareous than in the neighbouring Spiti area.

III.—“ Muth ” Quartzite.

In apparent normal sequence above the Upper Silurian horizon just described come vast thicknesses of very massive quartzite. The outcrop follows round that of the Upper Silurian, and makes a broad belt between it and the succeeding strata. Having regard to this well-established position and the character of the rock facies itself, it becomes extremely probable that this quartzite is the equivalent of the Muth quartzite of Spiti, etc.

In the main it is a massive quartzite, of granular texture, and of a generally white colour with spots and patches of ferruginous matter, (1) 23-6-09—in all of which characters it repeats exactly those of the

Spiti and Kumaun rock attributed to this horizon. In thickness it must be as much as 3,000 feet in places. Its lowermost beds become thinner-bedded siliceous shales where it passes down into the Upper Silurian.

No fossils have been found in it; so that, as in the case of Spiti and other areas, its exact age cannot be known; the only limits being Upper Silurian below and Lower Carboniferous above. It may therefore be of either of these ages, or it may be Devonian, or represent any two or all three of them.

It is unnecessary to do more than state (as the map shows) that this formation is everywhere found in contact with the Upper Silurian. Even at those localities where the latter has not as yet been established by fossil proof, the Muth quartzite has either been proved to occur, as near Paisan in the Arpat river, or can be recognised from afar as in the cliffs stretching N. W. and S. E. from the Margán Pass.

Unlike the Silurian and (?) Cambrian, it makes very prominent cliffs and precipices at the surface, especially where the dip is only moderately steep. Owing to the pitch of the axis of the anticline, it, like the formations below, disappears in the direction of the Lidar valley by the curving round of the strike, the last remnants of it in this direction being seen at Ainu near Eishmakám and at the N. E. end of the Kotsu ridge, which latter rises isolated out of the gravels of the Lidar river-bed.

IV.—*Syringothyris* Limestone Series (Lower Carboniferous).

With this markedly different formation we once more reach a set of beds which at two or three places are rather richly fossiliferous. In the Lidar valley, and probably in the Arpat river, the exposures of these beds coincide partly with areas marked by Lydekker as Kuling and perhaps supra-Kuling, but it is by no means evident that these particular fossiliferous horizons were detected by that observer, or that he collected from them. Certainly the chief fossil, *Syringothyris cuspidata*, does not appear among his collection as described by Diener (*Pal. Ind. Series XV*, Vol. 1, pt. 2, p. 77, 1899) who only mentions two specimens from Kuling in Spiti collected by Stoliczka, and which he (Diener) then observed were preserved in an entirely different rock from the ordinary Kuling shales, and hazarded the opinion that they came from a

lower bed. Later again (*Pal. Ind. Series XV*, Vol. I, pt. 5, p. 147, 1903), it is true, Diener was for the moment misled regarding this genus, which was, however, re-established by Hayden on the strength of more complete material (see *Appendix* to the reference above, added with Diener's approval).

When I wrote my previous paper on Kashmir (*loc. cit.* p. 319), I

L. Carboniferous horizon.

had only seen these beds at Eishmakám, but believed myself in possession of sufficient evidence to regard them as Lower Carboniferous, and as entering the sequence as noted there and in the Introduction to this paper, that is to say as separated from the Permo-Carboniferous (Kuling) by many thousands of feet of Fenestella shales, agglomeratic slate and Panjal volcanics. Since then the horizon has been traced by me almost continuously over a large area, including 12 miles on the N. E. side of the Silurian anticline from Kotsu in the Lidar valley to Hairbal Gali, whilst on the other side it is in evidence cutting across the ridge between Paisan and Tangamarg (Tanganrag of Atlas Sheet), and is only absent between that point and Kotsu by reason of the covering of alluvium. Beyond the Arpat river in a S. E. direction, as also beyond Hairbal Gali in the same direction, it apparently disappears from the section in company with the succeeding formations by what is regarded as the unconformable overlap of the base of the Panjal volcanics.

At the following localities the series is well exposed and has been collected from by me :—

- (1) Kotsu, isolated hill in the plain.
- (2) Eishmakám, on two hill spurs descending from Liwapatur Station.
- (3) 1 mile N. E. of Ainu (Azim of Atlas Sheet) at the tail end of a spur descending from "Peak No. 1."
- (4) Ridge north of pass between Tangamarg and Paisan, whilst the bed was identified (without collecting from) high up the valley above Gugaldar in two separate stream beds, and at the foot of the Hairbal Pass.

In all these places its position is between that of the underlying

Distinct from the Zéwan stage.

"Muth" quartzite and an overlying series, either the slates and quartzites which eventually merge into the Fenestella series (where these are preserved), or the agglomeratic slate and trap, where the latter has overlapped the Fenestella series. In other words its outcrop is separated by many

miles from any typical Zéwan Anthracolithic or Permo-Carboniferous outcrops, and it clearly has nothing whatever in common with them.

(1) *Kotsu, isolated hill in plain.*—Lat. $33^{\circ} 51\frac{1}{2}'$ long. $75^{\circ} 18'$.—The rock series is mainly calcareous with subordinate shales and sandstones or quartzite, and with a few bands of trap which may be intrusive. A typical section is given in Plate 34 of the Kotsu hill viewed from the N. W., where the main Syringothyris limestone below is 450 feet thick, followed by a trap band, a thin limestone band, and quartzites aggregating 300 feet which are in turn followed by about 100 feet of more limestone. Only the lower 450 feet were collected from, and of this two bands (2) 12-5-09 and (2) 15-5-09 were found to be specially fossiliferous. It is probable, however, that a similar fauna prevails obscurely right through the limestone mass, although the latter was too precipitous to yield more than a hard joint face at right angles to the dip and from which it was impossible to excavate.

This limestone is well-bedded, and of pale and dark grey colours. Where slabby or somewhat weathered, collecting is comparatively easy.

(2) *Eishmakám.*—Lat. $33^{\circ} 52\frac{1}{2}'$, long. $75^{\circ} 21'$.—In my previous paper (*loc. cit.* Pl. 33), I have drawn a section of the Eishmakám ridge from the locality of Ainu (Azim of map) which only differs in minor points from the above at Kotsu. In it also the fossiliferous layers are in the lower limestones—horizons (3) and (4) 5-9-08.

(3) *1 mile N. E. of Ainu (Azim of map)*—Lat. $33^{\circ} 52\frac{1}{2}'$, long. $75^{\circ} 22\frac{1}{2}'$.—Beyond the Ainu spur the Syringothyris limestone series can be seen crossing above the village in well exposed beds. After a short interval where they are lost beneath old moraine and boulder banks in the valley, they reappear as already stated at the above locality, which is exactly on the “am” of the word Eishmakám on the Atlas of India Sheet map. This is a long, pointed spur, tailing out west from a group of spurs descending from “Peak No. 1,” called “Krapri” locally.

About 150 feet of the limestone as before described can be readily examined. It is sometimes rather pinkish in colour. The upper middle part and upper part are specially fossiliferous, yielding the horizons (2) 14-6-09 and (1) 14-6-09, respectively, and a still lower horizon (3) 14-6-09, (the Syringothyris layer). But the whole section is fossiliferous, full of brachiopods, but so compacted into the rock that they cannot be extracted as a rule.

From this place the series follows the north side of the stream which flows S. W. or W. S. W. from Krapri, (Peak No. 1) and it would appear

that it eventually crosses the main ridge trending S. W. from that peak at a point a little north of a conspicuous gap, to reappear again in the next (Gugaldar) valley.

Besides the limestone proper, there are some sandy limestones as at Ainu, and also some traps of the usual basic kind, the exact relations of which were not seen. There is also a pale rock (4) 14-6-09, much crushed at the edges, forming a narrow vertical dyke only a few feet wide, and cutting across the strike.

(4) *Ridge north of pass between Tangamarg and Paisan in Arpat Valley*—Lat. $33^{\circ} 46\frac{1}{4}'$, long. $75^{\circ} 22'$.—This is the only locality where the series was found on the S. W. side of the Silurian anticline (for reasons as already explained). The exposure is probably duplicated by folding, but this is not certain. It is of considerable extent laterally, being traceable with breaks from the N. W. side of the gali (pass) overlooking the Lidar valley to near Paisan, a distance of over 4 miles. The dip of the series is reversed, which makes it apparently underlie the Muth quartzite at an angle of 60° , which latter occupies the ridge to the N. E. and has already been referred to as possessing a reversed dip at this place. At the same time it apparently overlies the Panjal traps or agglomeratic slate which here come in contact with it. The general direction of outcrop of the series follows a bridle road joining Tangamarg and Brear. In its N. N. W. extension its strike points directly to the Kotsu exposure.

The complication of stream beds and irregular spurs from the ridge down to the Arpat valley render difficult the deciphering and mapping of the precise irregularities noted above on a small-scale map.

Three good sub-sections are however seen, one a short distance N. E. of the gali where the road crosses the main ridge with fossil horizons (2) and (1) 4-7-09, a second (possibly faulted) low down on the road just before it emerges into the Brear valley, and a third 1 mile S. W. of Paisan with fossil horizon (1) 27-6-09. The last two are manifestly one band. Whatever the detailed explanation of the somewhat disjointed appearance of these two or three outcrops (faulting or folding of some kind), each perfectly repeats in inverted order the same general features and regular sequence in itself and as regards the Muth quartzite and Panjal volcanics (see Pl. 30, fig. 1). The individual sections make this evident, and also make clear the general agreement of the petrological facies of it with the Eishmakám and other sections.

It is of interest to note that whilst south-east of Paيسان in the Arpat river, the outcrop of the *Syringothyris* limestone series disappears for good under extensive alluvial deposits without any reappearance in the next mountain spurs (so far as they have been examined—the N. W. faces of these spurs are hopelessly forest and soil covered), on the other hand above Gugaldar, and at the base of the Hairbal Pass the approximation of the band in its outcrop to that of the Panjal traps can be seen to be a very gradual process, ending in the final extinction of it before arriving at the Margán Pass. Both at Gugaldar and Hairbal the series is definitely, though not well, seen. Traces of fossils also were found without difficulty, but the locality, lie, and partially obliterating presence of thick forest or covering moraine was adverse to spending time in collecting there.

In spite of the frequently continuous nature, and clearly defined position, of the outcrops of this very characteristic and mainly limestone series, and in spite of the numerous places where collecting was done, the fauna, as regards individual and distinctive species, remains very much where it was after my first season's collecting at Eishmakám alone (*loc. cit.* pp. 321, 233). All the localities have yielded much the same suite of fossils in the same grouping and relative abundance, whilst the negative evidence as to what the beds *do not* contain still stands as the most important criterion—apart from the field relations—for the conclusion that they constitute a single palæontological horizon quite different from either the *Fenestella* shales which come next above them or the Permo-Carboniferous at a much higher horizon.

The two most characteristic species, namely, *Syringothyris cuspidata*, Mart. and *Chonetes* (?) *hardrensis* var. *Tibetensis*, Salt. must still be relied on as the main connecting link, palæontologically, between this horizon and that of the Spiti (Kanaur) section described by Hayden. Hence if the latter on other evidence (*e.g.*, the presence, along with *Syringothyris cuspidata*, of *Phillipsia* cf. *Cliffordi*, Woodw. and *Helodus crenulatus*, Newberry and Worthen) must be relegated to the Lower Carboniferous, (Hayden, Geol. of Spiti, Mem. G. S. of I., Vol. XXXVI, pt. 1, p. 39, 1904) so these Kashmir *Syringothyris* beds must also be relegated to the same stratigraphical horizon. Other fossils collected by me, so far as determined, differ but little from those mentioned in my last report. *Productus lineatus*, Waag. is very common; *P.* cf. *scabriculus*,

Mart., *P. Cora* and *P. semi-reticulatus* are fairly common, together with the genera *Derbyia*, *Athyris* and *Rhynchonella*.

It is possible that a critical examination of this fauna may lead to more definite results. Meanwhile the positive separation of this series of limestones from the Permo-Carboniferous (Kuling of Lydekker), as a unit of provisionally Lower Carboniferous age may be accepted as being in harmony with all the stratigraphical evidence now at our disposal.

V.—Passage Beds.

Although the higher limits of the *Syringothyris* limestone series is fairly well marked, there follow above it some considerable thicknesses of unfossiliferous rock before the first bed of the *Fenestella* series becomes signalised by organic remains. These intermediate rocks consist of quartzites, sandstones and shales over the short area where they can be seen. Petrologically they might be linked with the *Fenestella* series above rather than with the limestone series below, inasmuch as they resemble the former in all save the lack of fossils, a disability which may even only be local and disappear with further search.

For the present, however, they are placed separately as "Passage beds," and they may be well seen $1\frac{1}{2}$ miles N. N. E. of Eishmakám, where, on the spur from Liwapatur Station descending W. S. W. to the canal bungalow, they occupy all the lower part as far as a line bearing S. E. by E. of Kollur. Above Ainu (Azim) N. E. up the valley opening between Liwapatur and Peak No. 1, the same may be seen up to 2 miles from Ainu, where *Fenestella* first begins.

VI.—*Fenestella* Series, ? Middle Carboniferous.

From Lydekker's map, descriptions and specimens, the exposures of these rocks in the Lidar valley were certainly included by him with his Kuling. They were examined by me during my first season in Kashmir at one locality only, namely, the little rocky spur on the left bank of the Lidar, S. S. E. of Dowhat and about $3\frac{1}{2}$ miles N. of Eishmakám. But even that brief glimpse of them, considered in conjunction with the series below and above, shook my faith in the isoclinal theory of Lydekker, and showed their distinctness from any of

Erroneously grouped with Lydekker's Kuling.

the ordinary Kuling or Permo-Carboniferous series of Vihi, Pailgam or Golabgarh. The great abundance of *Fenestella* and the very rare occurrence of (?) *Protoretepora*, without considering any other faunal elements, made me at once suspicious from a palæontological standpoint, whilst the solid appearance of normal sequence in the series in its position between the Syringothyris limestone and the agglomeratic slate and Panjal volcanics easily fell in with the simple theory of their real intermediate stratigraphical position, when once the Lower Carboniferous age of the Syringothyris limestone was accepted as probable.

Since last year, however, these *Fenestella* beds have been systematically followed round from point to point in their great loop of outcrop across the Lidar valley and in their many distinct occurrences, always in this intermediate position; so that now, on the strength of their field relations alone, it is impossible to regard them as anything but a set of deposits of older age than the Panjal volcanics, and younger age than the Syringothyris limestone, whilst they are of course out of all direct relation with the *Protoretepora ampla* zone or any other of the Permo-Carboniferous that appear in order only *above* that great thickness of Panjal volcanics.

The localities collected from by Lydekker and described as "north of Eishmakám" or as "8 miles from Pailgam down the valley," as well as his specimens themselves preserved in the Geological Survey type collection, make it fully certain now that we have arrived at last at one of the crucial points where I consider that Lydekker was misled. Returning for the moment to the palæontological argument, it needs but a glance at his specimens gathered from here and figured and named in Diener's monograph on the Anthracolithic Fossils of Kashmir (*Pal. Ind.* Series XV, Vol. 1, pt. 2) to see their total distinctness from the other species also therein described from Khunmu, Barus, Prongam or Pailgam, *i.e.*, from localities now known to be entirely distinct as to horizon. All those characteristic forms such as *Spirifer Rajah*, Salt., *Marguifera Himalayensis*, Dien., *Productus Abichi*, Waag., *Spirifer fasciger*, Keys., *Lyttonia*, *Spiriferina* cf. *Kentuckensis*, Schumard., *Camarophoria Purdoni*, Dav., etc., that appear with due precision at many or all the latter localities, are unknown at the localities marked "north of Eishmakám"; whilst, on the other hand, the abundant occurrence of *Fenestella*, *Spirifer Lydekkeri*, Dien., *S. triangularis*, Mart., *Strophalosia* and *Productus* cf

undatus, *P. scabriculus*, Mart., together with trilobites (*Phillipsia*) are peculiar to that locality and unknown from all the others.

Probably one of the causes which I conclude led Lydekker astray was a certain similarity between the facies of the rock matrix in which the *Fenestella* occur and that of the Permo-Carboniferous of the Vihi, Pailgam and Prongam deposits. But however close this resemblance (and it is not very close after all) it is not closer than that between the Upper Silurian, Permo-Carboniferous and Muschelkalk—as to the distinctness of whose horizons there can be no shadow of a doubt. Even more, however, was Lydekker misled perhaps by the seeming dissimilarity between these shaley bands and the hard solid quartzites with which they are intercalated. This difference in apparent metamorphism is no doubt here and there great, and might easily lead an observer to imagine it not unlikely that the shaley zones were infolded among the quartzites in the isoclinal way supposed by Lydekker; but examination of the intermediate layers between the two at very many places makes it clear that petrological passages occur, and that it is only when the siliceous material had become especially pure and unmixed with argillaceous material that a setting of the sandy matrix into a quartzite took place. In the local descriptions that follow, some examples of these passages will be given; whilst everywhere the interbedded character will be seen to be borne out by the continuity of outcrop right round and over the anticlinal, and the sequence preserved in the same way.

Above all, nowhere throughout the area is there any structural evidence of isoclines on their own individual merits. An isocline should preserve traces of its synclinal or anticlinal origin by being duplicated in the sequence of its beds from some central line or axis: but nothing of the sort is seen, whilst, on the contrary, each layer of shales between quartzite masses shows a definite petrological change only in one direction coinciding with what must be presumed to be the normal succession of the deposit as laid down in ordinary sequence with the sandy material of the quartzites.

In my previous paper I have already laid stress on the analogous sections in Spiti described by Hayden (Mem. G. S. of I., Vol. XXXVI, pt. 1, 1904) which very completely foreshadow the sequence of these Lidar valley sections as herein detailed; whilst it is plain from the quotations I there gave from that author's memoir that he also (without

having seen the locality) was impressed with doubts as to Lydekker's interpretation of that sequence being correct.

It will be understood from the preceding that I have treated the matter of this normal sequence with some elaborateness, not because I think my mapping and stratigraphical zones are in any way so obscure as to require special pleading to support them, but simply because such circumstantial proofs are in courtesy due to my predecessor, who, from one cause or another, was led to a different conclusion.

Accepting then the theory of normal sequence of these beds above the *Syringothyris* limestone series, we shall be prepared to accept a correlation of them with the Po series of Hayden in Spiti as being in every way reasonable, both on lithological, stratigraphical, and as we shall see later, on palæontological grounds. Their position between the *Syringothyris* beds and the real Zéwan or Permo-Carboniferous is therefore in entire agreement with that of the Po series, which in Spiti underlies the Permian conglomerate, which is followed in turn by the "calcareous sandstone" of Hayden, and then by the Productus shales (the real equivalent of part of the Zéwan stage in Kashmir).

The *Fenestella* series may generally be described as an enormous thickness (over 2,000 feet) of quartzites, in beds varying from a few feet to 100 feet, and with intervening layers of generally dark shales sometimes slightly calcareous. It is in the lower part that these shales become principally developed and also fossiliferous, carrying their rich bryozoon and brachiopod fauna; whilst towards the middle of the series the shales become less conspicuous and, so far as found, without fossils. Not far from the uppermost limits of the series, however, where they apparently pass into the agglomeratic slate, there recurs another *Fenestella*-bearing horizon, which is separated from the lower productive shales by an interval of 800—1,000 feet of unproductive rock. Along with the shales, and frequently more in the upper layers, occur ferruginous sandy beds that sometimes pass by gradation into the quartzites above.

The area over which this series is exposed is much more restricted than that of any of the previously described

Distribution.

formations, whilst it is generally coextensive with the overlying agglomeratic slate. Although the most characteristic sections are found on the banks of the Lidar river and at Lehindajjar, the series with fossils is also well marked in the valley head

between the S. W. spurs of Liwapatur Station and of Peak No. 1 (Krapri), near Buru and at the head of the Kirram Valley, whilst high above Gugaldar and the Syringothyris limestone, quartzites, but without fossiliferous shales (as recognised), appear in diminished thickness under the now approaching base of the volcanic series. Nowhere else to the S. E. in the area have they been recognised, and they thus suffer, in common with the formations below them, the overlapping effect of the Panjal traps, only they (as being higher beds) naturally disappear earlier.

The marked horse-shoe loop made by the bending strike, as the outcrops of the series return upon themselves among the ridges N. W. of Lidar, expresses the same anticlinal with axis pitching N. W., as was remarked in all the lower formations described. A break in the arrangement is however noticed along the Lidar where the outcrops on the N. E. side of the anticlinal are interpreted as being thrown apart by a cross fault along the valley at that point.

The following selected sections may be described here :—

- (1) Lehindajjar valley and base of Bhugmore¹ rasta.
- (2) Left bank of Lidar valley S. S. E. of Dowhat and Lur.
- (3) Head of Kirram valley.
- (4) N. N. W. of Buru, near Kotsu.
- (5) Valley N. E. of Ainu (Azim) between S. W. spurs of Liwapatur and Krapri.

(1) *Lehindajjar valley and Bhugmore rasta*—Lat. $33^{\circ} 55'$, long. $75^{\circ} 18'$.—Lehindajjar is a somewhat scattered upland village lying about 2 miles N. W. of and above Wallarhama, on the direct bridle road connecting the Lidar valley with the Traal valley by the pass known as the Bhugmore rasta. It also partly occupies the opening of a tributary valley of some size descending due south from the lofty peak, Churu (11,382 feet).² The bed of the Lehindajjar valley and portions of the connecting side valleys, lie flatly among the lower more shaley members of the Fenestella series, the latter by their disintegration producing a wide area of gently sloping culturable fields. Above these towards all points of the compass, but especially to the N. and N. E. of the village

¹ In the edition of the Atlas sheet, with corrections to 1904, on which the geology has been represented (Pl. 39) the word "Bhugmore" has been deleted. Bhugmore rasta is the pass over the ridge N. W. of Lehindajjar.

² The height of this and other trigonometrically fixed points is a few feet less than the values given on the old atlas sheets.

rise somewhat picturesque hill-spurs and slopes separated by water-courses, which, as they gradually emerge from their overburden of alluvium and gravels, yield some of the best sections in the *Fenestella* series. On the way up the valley from north of Wallarhama to the foot of the pass, these spurs, by the alternation of quartzite and shale, show very prominently the bending round of the strike from W. N. W.—E. S. E. to W.—E. and finally to W. S. W.—E. N. E. with corresponding dips to N. N. E., N., and N. N. W. of 40° .

The table that follows and the section (Pl. 31, fig. 1) show the smaller divisions or stages of the series, the table being in descending order :—

AGGLOMERATIC SLATE (ABOVE).

8. Uppermost *Fenestella* shales, containing also a branching bryozoon. Thickness small but unknown.
7. Quartzites and slates. No fossils. 500—600 feet thick.
6. Black, sandy shales with very few *Fenestella*. 100 feet thick.
5. Quartzite. 60 feet thick.
(Passage beds).
4. Shaley sandstones, dark grey and mottled greenish grey and black below. Traces of fossils. 200 feet thick.
(Passage beds.)
3. Dark shales full of *Fenestella*, corals, brachiopods and lamelli-branches.—(Camp horizon). 150 feet thick.
2. Quartzite. 60—100 feet thick.
1. Sandy shales or shaley sandstones, full of fossils as above. Many *Productida*.—(Ichindajjar Bed). 500 feet thick, (base not seen).

The shales and sandy shales of beds Nos. 1, 3, 4, 6 and 8—which sometimes might also be called imperfect slates—are penetrated by a rude cleavage. They frequently also contain pyrites pseudomorphs, even among the fossils. The internal evidence of the section just given, with its varied petrological sequence, obviously does much to dispose of the isoclinal theory; and even more so does the solid deeper structure of spur and ravine as laid bare by denudation. What with the latter and the deep cross-cut through the series made by the gorge from Churu we can follow the beds to the dip for many thousands of feet without any sign of wavering—any appearance of recurrent, reflexed folds which are necessary on Lydekker's theory. If, however, we were to assume that the reflexed isoclinal folds demanded by that theory might be of so great amplitude and so closely packed that even in this greatly

sculptured area they could appear as parallel beds, this would only make more impossible the bending round of the strike in loop fashion, a phenomenon which nevertheless is known actually to take place.

Of the fossiliferous more shaley layers in the Lehindajjar section just given, Bed No. 1, the lowermost and

Fauna.

more sandy division of the shales containing horizons (2) and (3) 24-5-09, is best exposed at Lehindajjar itself on both sides of the gorge descending from Churu Station. The fossils which are ferruginous casts embrace: *Fenestella* sp., corals, *Spirifer* cf. *grandicostata*, McCoy, *S. Lydekkeri*, Dien., *Productus* (?) *scabriculus*, Mart., *P. semireticulatus*, a few more indeterminate brachiopods and *Modiola*. Bed No. 3 (camp horizon), (2) 23-5-09, occurs higher up the valley at a point half-way between Lehindajjar and the foot of the Bhugmore rasta. It and the quartzites below are well exposed in the little ravine to the east of the bridle-road. A good collection, but poor in variety, was made here, embracing *Fenestella* sp. in predominating quantity and rather well preserved, a few corals, *Spirifer* cf. *grandicostata*, McCoy, *Modiola* and *Pecten*. In bed No. 4, (1) 26-5-09, which follows directly above No. 3, was found *Productus* cf. *scabriculus*, Mart. The rest of the shaley horizons above No. 4 yielded only a few *Fenestella* and some ill-preserved and much crushed brachiopods, together with a branching bryozoon in bed No. 8. The latter (the uppermost *Fenestella* bed,) (3) 27-5-09, was found *in situ* on the Bhugmore rasta, and identified by fragments high up in the Churu ravine.

(2) *Left bank of Jidar valley S. S. E. of Dowhat and Lur*—Lat. $33^{\circ} 55'$, long. $75^{\circ} 21'$.—The section here, which has its centre at the little cliff descending to the bridle road near the bridge and which was described in my previous paper, is almost equally convincing in its regular sequence through much the same set of beds, but the outcrop of the lower shales and sandy shales is partially obscured by a tangle of scrub jungle (see Pl. 31, fig. 2). The latter also appear much thicker, *i.e.*, continue further south than I had noticed when I wrote that paper. The full section by stages is as follows :—

AGGLOMERATIC SLATE (ABOVE).

6. Uppermost *Fenestella* shales with branching bryozoon,
 - (1) 1-6-09. Small thickness. At a point about 2 miles S. W. of Bhatkot.

5. Quartzites and shales. Large but uncertain thickness : the section could not be measured owing to recession of hill-spurs from the river-bed.
4. Ferruginous sandstone, (2) 13-9-08, (last year's number) (see section, Pl. 31, fig. 2). Twenty feet thick. Probably the equivalent of the top of "camp horizon" in the Lehindajjar section. This and the remaining numbered stages are all in continuous cliff section.
3. Great thickness of black *Fenestella* shales occasionally calcareous, sandy shales, with occasional more sandy beds and a little quartzite, and containing horizons (3) 13-9-08, (5) 13-9-08, (4) 13-9-08, (1) 6-9-08 (last year's numbers) and (1) 6-6-09, as shown in the section pl. 31, fig. 2. Thickness over 1,000 feet. Probable equivalent in part of Lehindajjar bed.
2. Trap (intrusive).
1. Quartzite and more *Fenestella* shales for an uncertain thickness until the passage beds (p. 222) are entered on the hill-spur above the canal bungalow at a point S. E. by E. of Kollur.

Of the above section it is practically certain that beds 3 and 4 represent those referred to by Lydekker as being "north of Eishmakám" and "8 miles from Pailgam down the valley" and from which his collection described by Diener was derived. A collection also made by F. Noetling in 1902 from 2 miles north of Eishmakám would seem to have been derived chiefly from these horizons. The specimens, registered Nos. K. 6. 514-586, remain unnamed and undescribed in the geological survey collection.

Fenestella and a few examples of (?) *Protoretapora* occur abundantly throughout the more shaley layers. In the lowest horizon collected from, (1) 6-6-09, there are also a coral, one small fragment of a trilobite, *Productus* cf. *undatus*, DeFrance; *P.* cf. *scabriculus*, Mart.; *Spirifer grandicostata*, McCoy; *Spirifer lydekkeri*, Dien.; *Rhynchonella* and other fragments.

An almost identical fauna appears in (1) 6-9-08, (last year's number) found in large loose blocks, by the river side near the Fakir's hut, and which may have been derived from near the same bed. During my previous visit I accorded it a position too close to (4) 13-9-08 and assumed

it, probably erroneously, to be approximately *in situ*. The rock is calcareous in parts.

The horizon (4) 13-9-08 (last year's number) is prominent as appearing in cliff section actually at the Fakir's hut and cave overlooking the road. A large number of *Phillipsia* fragments characterise this bed, together with *Modiola* and most of the species in fragmentary state as given above. From the prominent aspect of the bed, the contained fauna, and the nature of the rock matrix, this was clearly one of the main sources of the specimens gathered by Lydekker. It is calcareous in patches.

Horizon (2) 13-9-08 (last year's number) which is more sandy than any of the others, presents the forms *Dielasma* (large species) *Spirifer* cf. *triangularis*, Mart., a few other undetermined species of *Spirifer*, *Productus semireticulatus*, Mart., *P. scabriculus*, Mart., a large *Camorphoria* and *Eumetria* cf. *vera*, Hall.

The continuous cliff section by the bank of the river ends with this bed, as shown in the figured section (Pl. 31, fig. 2). Stages 5 and 6 of the table given at p. 228 are only seen in discontinuous exposures in the side-streams and side-spurs as they recede from the main river bank beyond the bridge. The map is too vague in topographical details to further define these outcrops, but the overlying agglomeratic slate sets in some little distance before the important side-stream opposite Lur is reached.

From the above sketch of the fauna as provisionally determined by me, we may now rest certain that these beds as a whole are the ones collected from by Lydekker 8 miles from Pailgam down the valley and described by Diener (*Pal. Ind.* Series XV, Vol. I, pt. 2.). Their agreement also petrologically, and as to their prevailing fossils (the great abundance of *Fenestella*, *Productus unilatus* and *P. scabriculus*), with the Po series of Kanaur, Spiti, described by Hayden (Mem. G. S. of I., Vol. XXXVI, pt. 1, pp. 49-50) seems also to be beyond dispute, especially since they appear in exactly similar sequence as regards the formations below and above, only excepting the trap beds of the volcanic series which seem to be absent in Spiti, at least as regards sub-aërial flows. Much of the grits along with the Permian conglomerate of Hayden, which are described as lying above the *Fenestella* series, must, undoubtedly, correspond to my agglomeratic slate. The description of the former as being "composed of angular and rounded fragments of shale and limestone embedded in a coarse slaty matrix" (*loc. cit.* p. 51)

agrees perfectly with much of what I have classified together under the comprehensive title of agglomeratic slate.

It only remains to point out that Hayden's correlation of his Po series with the Zéwan beds of Kashmir must now, in the light of my later work, be understood to be only a correlation with the Fenestella beds of the Lidar valley, which, having been wrongly grouped by Lydekker with those Zéwan beds, came to have their fauna described by Diener along with the fauna of the latter.

A structural feature of some interest in connection with the sections just described is the cross-fault down the Lidar valley. If the strike of the Fenestella shales S. E. of Dowhat which is N. W. by W. with a dip to N. E. by N. of 30° , is considered, it will be seen that the outcrop of the same, if uninterrupted, should cross the valley and reappear on the other side between Kollur and Dowhat; whereas such is not the case, and all that stretch of country is occupied by the agglomeratic slate. To explain this hiatus a fault is assumed along the bed of the river at this place. This fault, however, would appear to have died out higher up the valley where the Panjal traps make their appearance in the section, inasmuch as the outcrops of the latter meet at the river, having suffered no displacement at all.

(3) *Valley N. E. of Ainu (Azim).*—Away from the actual bed of the Lidar river to the S. E. the Fenestella series can be followed across the spur which descends W. S. W. from Liwapatur Station to the canal bungalow ($1\frac{1}{2}$ miles N. N. E. of Eishmakám), and from there across the intervening spurs to the valley N. E. of Ainu. Here at 2 miles N. E. of that place the series extends for some considerable distance up the valley. There are no good continuous sections, but enough is seen to completely identify them (see camera sketch Pl. 33.)

The high spurs between here and the Gugaldar valley were not actually crossed by me, and as already mentioned the section high above Gugaldar is much covered, and only the quartzites of the series were exposed in their much thinner outcrop here. It is practically certain, however, that all these spurs would yield abundant traces of typical fossils if sections free of soil, forest, moraine or talus could be found.

(4) *Head of Kirram Valley* — Lat. $33^{\circ} 54'$, long. $75^{\circ} 15'$.—From Lehindajjar and the east slopes of the Bhugmore rasta the boundary

between the Fenestella series and the agglomeratic slates, though not followed for the next mile or so, has been limited within very narrow confines by work on both sides of the main ridge. Beyond that it is again found fairly sharply defined at the head of the Kirram valley at a point 3 miles N. N. E. of Kirram, where the series is characteristically developed with plenty of fossils, (1) 8-8-09, though there is no good section. With a steep S. W. dip, and strike N. W.—S. E., the same continue and were next found by me near Buru in the valley of the Lidar again.

(5) *Buru* — Lat. $33^{\circ} 51'$, long. $75^{\circ} 18'$.—Here at Buru it will be perceived that we have arrived at the S. W. side of the grand anticlinal, and the identification of representatives of the Fenestella series at this point was not a difficult task when once their position was presumed from, and limited by, the Syringothyris limestone of Kotsu and the agglomeratic slate above. There are some hundreds of feet of the shale probably not all fossiliferous, good fossils being found in a bed 50 feet thick at a point at the foot of the hills due E. by N. of Shari bal station and N. W. by N. of Buru village, (1) 13-5-09. They continue up the slope and are found also on the ridge of the near spur. They dip 60° S. W., and pass beneath and possibly up into the agglomeratic slate.

PANJAL VOLCANIC FLOWS AND AGGLOMERATIC SLATE.

This great series of rocks which I have used as a convenient dividing series between divisions A and B of the fossiliferous formations, is characterised by very definite basic lavas in its upper part, and by what I have called agglomeratic slate in its lower part. The two constitute Lydekker's Panjal trap and Panjal conglomerate, respectively, and are frequently found together over large parts of Kashmir, being well developed in the Pir Panjal, or Panjal range, from which the series takes its name.

Whilst the upper traps are eminently characteristic volcanic flows, the lower agglomeratic slate presents some difficulties. That it is a clastic rock of some kind seems to admit of no doubt. Much of it from its dark grey colour and the nature of its matrix might be described as a fine grit or greywacke, composed chiefly of angular grains of quartz set in a still finer vague matrix which was probably once of the nature of clay, rock

flour or ash, or it may partly be cataclastic mylonite. But dotted about at random through this matrix occur larger fragments, sometimes rounded, but more generally sharply angular (like the smaller grains of quartz) and composed of quartz, felspar, slate and quartz-porphyry, with occasional quartzite, pegmatite and even tourmaline-granite fragments. These range in size from bits as large as a pea to others the size of the fist. When they become very large the rock becomes generally much more quartzose and the larger pieces are then more rounded. The finer-grained rock is the predominant rock and is easily recognised wherever occurring by the angular fragments or by the cavities whence such fragments have been weathered out on exposed surfaces. It is generally imperfectly cleaved, in common with all the fine-grained rocks of this region.

But having acquiesced in its clastic origin, it is not so easy to define the exact nature of the agency by which it was accumulated. It is certainly not a simple stratified deposit laid down under the action of water. Although the sharply angular nature of the smaller quartz grains forming the matrix might not have been altogether adverse to this conclusion, the angular state of the larger fragments demands some other explanation. There seem to be two main natural agents by which such a wide-spread and uniform deposit might have been accumulated, namely; (1) explosive volcanic action, and (2) frost with ice transport.

If we accept the former as being congruent with the lavas which followed, we have to admit the entire absence of glassy or pumiceous material in the rock matrix as now seen, although subsequent devitrification or silicification with crushing and development of mylonite, sericite, calcite and other secondary minerals might account for the condition of the rock as we now see it.

On the other hand, if we accept the alternative explanation for the origin of such a rock which in many respects resembles the Blaini conglomerate (the glacial origin of which seems now beyond dispute —see Rec. Geol. Surv. of India, Vol. XXXVII, pt. 1), we must nevertheless admit that no striated, grooved or faceted boulders have so far been found in it. In this connection it is of interest to note that the first fossiliferous horizon found above the agglomeratic slate and undoubted volcanic traps, namely, the *Gangamopteris* and *Psygmyphyllum* bearing beds of the Golabgarh pass (Rec. Geol. Surv. of India, Vol. XXXVII, pt. 4, p. 293) are very probably of Talchir age or at least of Lower Gondwana age, and

that therefore the agglomeratic slate might after all synchronise fairly well with the wide-spread glacial boulder deposits of that age in South India, the Salt Range, and other austral regions.

Although unable to discuss the subject here (I shall hope to do so in another paper) I incline to the explosive volcanic theory, and so include the agglomeratic slate as the lower member of the volcanic series. That is to say I regard it as an accumulation of clastic and sedimentary material formed round ruptured portions of the earth's crust which eventually became foci for the extrusion of basic lava flows. At the same time the alternative hypothesis should not be lost sight of, nor the possibility that the formation was a joint product of both sets of activities combined with ordinary sub-aërial sedimentation.

One factor in the question which should not be overlooked is that the agglomeratic slate, even in its finest-grained varieties, contains no organic remains throughout the whole thickness of the formation. Although it is probable that the Fenestella shales in their uppermost layers pass up into the agglomeratic slate without any break in the continuity of deposition, every trace of fossils ends when the material begins to be agglomeratic. Unfortunately, however, the absence of organisms might be understood under either supposition as to the mode of formation of the rock, so that we are left as before very much in the dark on this point. Only one conclusion seems to emerge as satisfactorily demonstrated, namely, that the rock is no ordinary slate or greywacke deposited under normal marine conditions such as obtained when the Silurian or Fenestella shales were laid down.

As shown by the map, the agglomeratic slate interbanded with a few quartzites occupies what is generally a wide outcrop of horse-shoe shape following round the outer margin of the Fenestella shales and dipping with them at about 40° on the N. E. side of the anticlinal and at about 60° on the S. W. side. The limit of the outcrop at the N. E. extremity of the horse-shoe as far as can be ascertained is coincident with the limit of the Fenestella shales, but on the S. W. side the outcrop, with much diminished thickness, continues almost as far as the trap itself. The agglomeratic slate is everywhere of a very crumbling nature and rapidly disintegrates under weathering and is slightly calcareous in places. It is unnecessary to describe any special sections in this rock series. At Buru in the southern part of the Lidar valley ; and again further north

between Kollur and Virsiren, as well as further west on the east slopes of the Traal valley and the ridges and slopes about Churu Station, enormous thicknesses are laid bare, dipping steeply towards regularly varying points of the compass under the Panjal traps as the strike changes in conformity with that of the succeeding beds both below and above.

After what has already been said regarding the underlying *Fenestella* shales, the *Syringothyris* limestone, Muth quartzite and Upper Silurian slates, it is enough merely to remark in passing that this formation is entirely unrelated to the much older Silurian and (?) Cambrian greywackes in the Harpatnar, Arpat, Naubug and Maru Wardwan valleys.

The question as to whether one would be justified in similarly separating all the occurrences of Panjal conglomerate mentioned by Lydekker in his memoir from the presumably much older slate series bearing the same name is not of course easy to decide. From my own knowledge I can only be certain of one other area, namely, that of the Pir Panjal range in the neighbourhood of the Golabgarh pass. There, although I did not detect any fossiliferous rocks coming below the anticline of agglomeratic slate, I found the latter at every point underlying volcanic traps which in turn underlie Lower Gondwanas, followed by the Zéwan or Permo-Carboniferous.

With regard to the traps themselves, only a brief reference here will be attempted. They are distinctly bedded and very massive (see Pl. 28 showing the crags above Gugaldar). Amygdaloidal and compact bands are both very common. Many specimens of these rocks were submitted by Mr. Lydekker to General McMahon, whose descriptions are quoted by that author (Mem. XXII, p. 218, *et seq.*). My own collection and rock slides corroborate their identification of them as genuine old basic lava flows. Their greatest thickness like that of the agglomeratic slate must amount to many thousands of feet. None are porphyritic, all the specimens that I have collected being altered microcrystalline aggregates of basic feldspars and finely granular augite with iron ores, and here and there traces of glassy base. No olivine is present.

The outcrops extend with or without the agglomeratic slate, as already stated, far to the S. E. of the immediately underlying *Fenestella* and *Syringothyris* beds so that there is successive overlap or unconformity between

them and those underlying formations, until in the Naubug valley and on the Margán pass they repose directly on the Muth quartzite with only a thin conglomerate between. In all these places, as also in the Golabgarh pass, they build fine walls and precipices of rock and fill the ravines at their feet with enormous blocks and boulders detached from them. The map and sections will further illustrate the general extension of these beds both S. E. of the Lidar valley and also N. W. to join up with the Wastarwan and Zebanwan masses. Although unconformity or overlap is indicated above all the lower formations, their present general lie with steep dips of from 40° to 30° on the N. E. side of the anticline is generally conformable with that of the subjacent groups, at least there is no marked discordance between them. The same is true in their steeper lie on the S. W. side of the anticline and their vertical or even inverted position near Naubug and Paisan (see general sections across the anticline.)

In addition to the bedded traps, other parts of the area, as for instance the Lidar valley near Kollar, show dykes of what most likely was the same magma, cutting through the agglomeratic slate on one side of the valley and through the Fenestella shales on the other. Similar dykes or laccolitic masses are found between Mandra and Batton in the Traal valley. Of these undoubtedly igneous lavas and dykes as well as of the underlying agglomeratic slate I hope to give a description in a separate paper.

DIVISION B—ABOVE THE VOLCANIC SERIES.

VII.—Gangamopteris Beds (Lower Gondwanas).

In my previous paper on Kashmir I have described the occurrence of a thick series of siliceous and carbonaceous shales and of hard grey sandstones and carbonaceous shales, the latter containing characteristic Lower Gondwana plants, as lying directly above the volcanic traps in the Golabgarh pass. In the area treated of in this paper these beds are reduced to the very thin layer of Gangamopteris-bearing shales of the Risin spur and neighbourhood which have already been fully described by previous observers (for references see my previous paper).

The only fresh locality within this area brought to light during last season's explorations is the extremities of two spurs, 3 miles E. by S. of Pansapura.

Near Pansapura.

(lat. $33^{\circ} 51'$, long. $75^{\circ} 11'$) at the S. S. W. foot of the Kamlawan mass of trap rocks (5,601 feet), which mass is the counterpart of the Wastarwan mass on the opposite side of the opening of the Traal valley. Here, although only a doubtful *Gangamopteris* was found, there is a thickness of 200—300 feet of carbonaceous and siliceous shales and a few limestones, coming directly above the massive trap, and which there is a strong probability are the equivalents of the *Gangamopteris* beds of Risin spur. The shales weather white, just as at Risin and Zéwan. They are frequently silicified, as also are some of the limestone beds. Specimen (1) 9-8-09 is a sample of these shales with plant impressions and *?Gangamopteris*.

The sequence in these spurs differs from that of all the others in the neighbouring areas by the plant-bearing shales being overlaid by more trap and fine ash, 200—400 feet thick, and which appear to take the place of the lower part of the Zéwan beds inasmuch as they in turn are followed by a massive grey bryozoon limestone with *Camarophoria*. As the section is then obscured by alluvium and surface accumulations it is impossible to be certain on this point.

VIII.—Zéwan or Permo-Carboniferous.

With reference to the succeeding Zéwan or Permo-Carboniferous beds, it is unnecessary in this note to do more than draw attention to one or two new localities whence characteristic fossils have been obtained, and to add a few particulars to one or two of the sections in the Vihi area described in my last paper, which otherwise fully illustrates the sequence of these strata.

It will be seen that the new, more comprehensive, map with this paper continues the outcrop of the Mandakpal horizons beyond that village in an E. and N. N. E. direction across the Patarkul R. *via* Pastannah (Pastooni of the Atlas sheet), Lám and Narastán. These localities all lie along the line of outcrop as correctly marked by Lydekker on his original map.

I will first of all refer to the old localities of the Guryul Ravine and Mandakpal, where one or two new horizons must be inserted and a slight modification of my last year's section is required.

(1) *Guryul Ravine*.—If the reader will refer to plates 29 and 30 of my last paper (Rec. Geol. Surv. of India, pt. 4, 1909) he will find a set of dark, sandy, micaceous shales indicated on the spur above the Chenar

trees at the entrance to the gorge. These follow above the *Protoretetepora ampla* horizon, and in 1908 yielded no definite fossils for the first 400 feet above that bed. Last year (1909) I was fortunate enough to find a new horizon at a point about 100 feet above the *Protoretetepora* bed. It is calcareous and lenticular, about 1 foot thick, occurring among the sandy shales on the arête exactly on a level with the summit of the Chenar trees, (1) 10-10-09. It contains well-preserved specimens of *Productus semireticulatus*, Mart., and *P. cf. Gangeticus*, Dien., in large numbers. Another smaller bed 50 feet above this, (2) 10-10-09, contains *Athyris* sp.

(2) *Mandakpal*.—If the reader will also refer to plate 32 of my previous paper (upper figure) he will find three points of outcrop marked (2) 14-8-08, which (p. 311 of that paper) were rather doubtfully referred to one continuous horizon. The same bed also seemed doubtfully duplicated in the section 2 miles north of Barus (p. 315). I have now ascertained that in the former section there are really two separate horizons embraced under the number (2) 14-8-08. The lower of these is the one marked as “best fossil locality,” whilst the others at the two points marked with the same number are really somewhat higher in the scale and are characterised by containing *Spirifer Rajah*, Salt. in predominance, almost to the exclusion of everything else. The matter was definitely settled by my finding the latter *in situ* directly on the slope above the “best fossil locality” and by my tracing the “best fossil locality” exposure almost continuously along the slope to the distant ridge slope shown in plate 32, where it should be inserted as cutting the spur between the points there marked (2) 14-8-08 and (1) (2) 16-8-08, respectively. The upper bed I have now indicated by the number (1) 2-10-09, and it may be easily distinguished from (2) 14-8-08 by the fact that it contains no *Marginifera Himalayensis* and no *Productus Cora*.

Two other less important horizons were found above and below (1) 2-10-09 respectively, so that the sequence of horizons in the Permian-Carboniferous of Mandakpal now becomes as follows in descending order as far as the *Protoretetepora ampla* limestone:—

(0) 2-10-09, containing corals and *Chonetes* in matted groups.

(Ten feet of unproductive sandy shales.)

(1) 2-10-09 [previously included with (2) 14-8-08] containing *Spirifer Rajah* in predominance, a somewhat broader form perhaps than in (2) 14-8-08. Other species found were *Spirifer fasciger*, Keys., *Chonetes*, and a *Productus* of the *fimbriati* group.

(Ten feet of unproductive shales.)

(2) 2-10-09, containing *Athyris*, corals and *Productus* of the *fimbriati* group.

(Fifty feet of unproductive sandy shales.)

(2) 14-8-08, (equivalent of "best fossil locality" of plate 32), containing in the uppermost hard dark limestone *Spirifer Rajah*, *Marginifera Himalayensis* and *Productus Cora* in large numbers with rarer *Diclasma LaTouchei*, *Athyris*, *Camarophoria* cf. *Purdoni*, *Spirifer Nitiensis*, Dien. S. sp., *Spiriferina Kentuckensis*, Shumard., *Productus Abichi* or *gangeticus*, Dien., corals (*Amplexus*?) and *Aviculopecten*.

In the lowermost layer of shales below the limestone there are chiefly *Marginifera*, *Spirifer Rajah* (a small variety), corals, *Lyttonia* and *Aviculopecten*.

(Eighty feet of unproductive shales.)

(1) (2) 16-8-08 and *Protoretepora ampla* horizon.

I collected very largely from horizon (2) 14-8-08, and my specimens now number some hundreds of each of the three chief forms, some of which are very well preserved, and include many specimens of *Spirifer Rajah*, complete with both valves; whilst all the other species are well represented by many examples. This bed at Mandakpal, indeed, may be regarded as one of the richest and best preserved of any of the life zones in this part of Kashmir. The genus *Camarophoria* is represented by a form intermediate in size between *Purdoni*, Dav. and *gigantea*, Dien.; some other forms of *Camarophoria* in this bed, however, differ very widely from these two typical shapes and will probably constitute new species.

I was also able to add considerably to my collection from horizon (1) 16-8-08 of last year.

(3) *Pastunnah* (*Pastuni* of *Atlas Sheet*—lat. 34° 0', long. 75° 8'). To reach this locality from Mandakpal one must cross over the pass to the east which carries the bridle-road connecting Mandakpal with the Patarkul¹ and Traal valleys. The village lies on alluvium and talus fans, which descend from the neighbourhood of the pass to join the river gravels in the Patarkul valley. Away to the south-west the massive beds of the Wastarwan Panjal traps can be seen descending in great sheets with dip slopes to the north at fairly steep angles. But attached to the upper beds of these and near the base of the slopes there are secondary little spurs given off, introducing Permo-Carboniferous

¹ Written "Patark" on the new atlas sheets.

rocks and (as we shall see later) Trias. Owing to the thick forest covering these slopes there are no good sections. To the S. W. of the village, however, and 200 feet above it the upper *Spirifer Rajah* bed (1) 11-9-09, was found with *Productus* cf. *gangeticus*, Dien. etc., among sandy shales of the usual kind. Below it there were 50—100 feet of more sandy shales and then grey limestone with no fossils for 100 feet. The section is then interrupted by a stream-bed, behind which come the first sheets of the Panjal traps. At this locality, therefore, it will be seen, there are no traces of the *Protoretetpora* limestone. In the other direction above the *Spirifer Rajah* zone the series continues in the ordinary way for some distance, and then becomes gradually more calcareous as we approach the Lower Trias (see p. 242).

(4) *Lám*—lat. $34^{\circ} 2'$, long. $75^{\circ} 10'$, and *Narastán*—lat. $34^{\circ} 4'$, long. $75^{\circ} 10'$.—From Pastannah to near *Lám* surface deposits cover the junction of the trap with the B division of the fossiliferous series. At *Lám* itself, also, the Permo-Carboniferous rocks are not seen on account of a side stream descending directly along the line of outcrop of these beds. At *Narastán*, however, in the next little side valley to the north there are a few traces of dark micaceous sandy shales, about 150 feet thick, (1) 23-8-09, from which *Productus semireticulatus* and a few other brachiopods were obtained. Here, however, as at *Lám* the actual junction of the overlying beds with the Panjal traps could not be detected on account of the side ravines and forest. The evidence, so far as it goes, points to the Permo-Carboniferous being represented here; but the failure to find the characteristic *Protoretetpora ampla* zone either here or at Pastannah makes me suspect that there may be a dying out of this formation in this direction. Still further to the east in the isolated outcrops of Permo-Carboniferous and Trias at Pailgam, as was noticed during my first season in Kashmir, the Permo-Carboniferous formation was very imperfectly developed.

The strike at *Lám* and *Narastán* varies from N. N. E.—S. S. W. to N.—S. with steep dips to W. N. W. and W. respectively.

IX.—Trias.

The preceding year, 1908, it will be remembered that a *Meekoceras* horizon of the Lower Trias was discovered by me in the sections E. of the Guryul ravine near Khunmu in the Vihi district, together with a probable

New fossil horizons.

representative of the Muschelkalk above it. I was particularly fortunate again last year, 1909, in my examination of the Trias formation along the newly explored line of outcrop between Mandakpal and Narastán, and in my re-examination of the Khrew and Khunmu areas visited the season before. The neighbourhood of Pastannah was especially prolific in good sections with abundant horizons of characteristic cephalopods, many of which are well preserved. They include an *Ophiceras* horizon in the Lower Trias and a very full sequence in the Upper Muschelkalk comparable to many of the Central Himalayan sections in Garhwal and Kumaun. What are presumed to be representatives of the Upper Trias have, however, so far yielded no cephalopod fauna, though there are many brachiopods and lamellibranchs. The *Otoceras* horizon at the base of the Lower Trias is also still wanting in this area.

The following statement in tabular form gives a summary of the Trias horizons so far detected in this part of Kashmir:

UPPER TRIAS. (Many thousands of feet thick).	{	Unfossiliferous massive limestones.
		<i>Spiriferina Stracheyi</i> and <i>S. Haueri</i> zones.
	{	Lamellibranch beds.
MUSCHELKALK. (About 900 feet).	{	<i>Ptychites</i> horizon: sandy shales with calcareous layers.
		<i>Ceratites</i> beds: Do.
		<i>Rhynchonella trinodosi</i> beds: Do.
		<i>Gymnites</i> and <i>Ceratites</i> beds: Do.
		Lower nodular limestone and shales.
		Interbedded thin limestones, shales and sandy limestones.
LOWER TRIAS. (Over 300 feet).	{	<i>Hungarites</i> shales (position uncertain).
		<i>Meekoceras</i> limestones and shales.
		<i>Ophiceras</i> limestones.

(a) LOWER TRIAS.

1. *Pastannah* (*Pastuni* of *Atlas sheets*: lat. 33° , $59\frac{1}{2}'$, long. $75^{\circ} 8'$).—Whilst working out the excellent sections in the Muschelkalk at this place, I was unduly detained by a spell of rainy weather, and my attention was then drawn to numerous blocks of clear, dark, blue-grey limestone among the gravel and detritus fans near the village, and which

were seen to contain a very well preserved *Ophiceras* fauna. It was some time before I was able to track these to their home *in situ*, where they occupy (as shown in the camera sketch, Pl. 35) the secondary little spurs (mostly forest-covered) W. by S. of Pastannah village, referred to p. 240. The outcrops are very imperfectly shown because of the prevailing forest and soil-covered dip slopes, but their position as overlying the Zéwan (Permo-Carboniferous) and underlying the Muschelkalk, admitted of no doubt. They consisted of blocks *in situ*, and occasional definite layers of dark grey, compact limestone, protruding from the soil-cap of the occasionally-found barer slopes.

The apparent dip follows that of the beds below and above and is approximately 40° N. N. W. Owing to the down-hill dip, it is not easy to estimate the thickness, but there must be at least 300 feet, of which some 50 feet are specially fossiliferous, [(1) 5-9-09].

The commonest form of ammonite in these lowermost Trias limestones is present in great abundance, single blocks often yielding a large number of specimens compacted together. Occasionally individuals may be broken out from the rock in a very fair state of completeness and preservation. A large percentage seem to belong to Diener's amplification of Griesbach's genus *Ophiceras* (*Pal. Ind.*, Series XV, Vol. II, Pt. 1, p. 100) although in no single instance is there visible any of the delicate concentric or spiral striation that is supposed to characterise the innermost layer of the shell. Other differences are to be found in the transverse section which is never cordate, only occasionally lanceolate, and generally roughly oval with no well-marked umbilical margin or wall.

Nevertheless, the general similarity of the forms in size, shape, ornamentation, sutures and range of variation to those united by Diener into his group *Ophiceras Sakuntala* cannot be denied, and with this group therefore I am compelled provisionally to classify them.

Ophiceras, according to Diener, is entirely restricted to the lowest division of the Trias, the *Otoceras* beds. As already remarked, the latter genus is apparently wanting in this part of the Kashmir area, so that it is quite possible that the forms discovered by me may be slightly different in horizon and exact affinities.

The two species of this group to which most of my specimens most nearly correspond are those of *O. Sakuntala*, Dien., and *O. ptychodes*, Dien., but the two seem to pass into each other by transitional forms,

whilst there are others, *Ophiceras* sp., with characteristics which seem to connect *Ophiceras* and *Xenodiscus* (*Danubites*).

An almost equally large percentage of ammonites in this bed belong undoubtedly to the genus *Xenodiscus* (*Danubites*). Several species seem indicated, but I have not attempted to sort them out specifically. All or most have a general similarity to the species described by Diener and von Krafft (*Pal. Ind.*, Series XV, Vol. II, pt. 1, and Vol. VI, pt. 1). There are also a few other undetermined fragments of ammonites.

Orthoceras and *Pseudomonotis* are represented by a fair number of specimens.

All the above have been gathered both *in situ* on the hill outcrops and from loose blocks in the detrital fans, but a few other forms, a ? *Proarcestes* (one small specimen) and about 40 well-preserved small specimens of *Hungarites*, one *Xenodiscus* and some *Meckoceratidae* were only found in the detrital material. They occur in a shaley matrix, which I much regret having been unable to locate *in situ*. As the nature of the matrix is so different from the normal Lower Trias it cannot be presumed that these specimens of *Hungarites*, etc., really came from the Lower Trias, and they may have been derived from some other higher horizon. This unknown horizon has been indicated by (X) 4-9-09.

On returning to Calcutta Mr. Hayden drew my attention to a quantity of fossils already in the Survey collection from this locality, Pastannah (Pastooni), gathered by F. Noetling (K. 6. 58, K. 6. 108 in the Fossil Register) and identical with those of horizon (1) 5-9-09. No details concerning them are to hand, the Register simply giving the name of the village without any further comment. It is probable that Noetling obtained them, as I did at first, from loose blocks, as there was no sign of any previous excavating at the *in situ* places whence I collected.

(2) *Lám*—(lat. $34^{\circ} 2'$, long. $75^{\circ} 10'$).—Between Pastannah and Lám the recent gravel banks and fans of the Patarkul R. hide outcrops of the Lower Trias. At Lám itself, on a small spur immediately north of the village, some rather doubtful dark grey limestones, of which 300 feet are exposed, very probably represent the upper part of the Lower Trias. Some obscure traces of *Pseudomonotis* and of ammonites were found in horizon (3) 20-8-09, near the top of these limestones and just below a marked cattle track winding up the spur from the village and also in horizon (4) 20-8-09 about 50 feet above (3) 20-8-09 (see camera sketch, Pl. 38). No trace of the *Ophiceras* horizon of Pastannah, however, was

found there, and there is good reason for supposing that its position is still lower in the section and buried out of sight by the detrital accumulations somewhere in the neighbourhood of Lám village itself.

(3) *Narastán*—(lat. $34^{\circ} 4'$, long. $75^{\circ} 10'$).—At this village, however, there seems to be a perfectly continuous section from the presumed Permo-Carboniferous sandy shales with *Productus semireticulatus*, etc., (1) 23-8-09, into a set of thin-bedded, dark grey limestones, which, some hundreds of feet above (1) 23-8-09 and immediately above Narastán village, contain numerous ill-preserved traces of ammonites, (2) 23-8-09. The specimens are much and deeply weathered, but there is good reason for thinking that they are the real representatives here of part of the Lower Trias, the rock being very similar to that at Pastannah. But, from the fact that no typical *Ophiceras* layer was found in this very clear section, one is tempted to conclude that it is really absent, having died out just as seems to have been the case with other still older horizons (e.g., the *Protoretpora ampla* zone). Deficient observation may, however, still be shown to be the true cause of this apparent absence, inasmuch as the Lám and Narastán sections were visited before the Pastannah Lower Trias horizons had been discovered.

(6) MUSCHELKALK AND UPPER TRIAS.

Whilst the Lower Trias, when present, is only found poorly exposed on obscure dip-slopes, as for instance to the south of the valley leading down from the pass to Pastannah; the representatives of the Muschelkalk and Upper Trias are well exposed, and occupy the base or lower part of a long line of scarps that rise with increasing steepness as higher and more massive beds of the Upper Trias appear, and which finally build an array of picturesque crags and precipices towering high above the surrounding country. As these sections are everywhere continuous upwards from the Muschelkalk into the Upper Trias, and as the uppermost limits of the former are not precisely known, it will be well to take the two together in the present description of them.

(1) *Pastannah*—*Pastuni of Atlas sheet*: lat. $33^{\circ} 59\frac{1}{2}'$, long. $75^{\circ} 8'$.—Immediately to the north of the detrital fan on which the village is situated rises a conical shaped hill-spur which is seen to be connected by a little neck, forming a marked gap, with the higher continuation of the same spur leading up to the culminating wall of crags. A *camera lucida* sketch of the spur is shown in Plate 36 and a section of it and the succeeding horizons above in Plate 32.

The base of this conical hill begins with 200 feet of dark grey, rather thin-bedded limestone, containing no fossils with the exception of a few occasional lamellibranchs. The dip of it and the succeeding strata is 30° - 40° N. N. W. Whether this bed belongs to the Lower Trias or to the Muschelkalk is uncertain, but petrologically it more nearly resembles the former. This changes somewhat abruptly into 200 feet of interbedded thin limestones and shales, of a buff colour, amongst which also no fossils have so far been detected.

We then pass into grey-coloured, thin-bedded, rough-weathering, sandy limestones, with a lamellibranch horizon, (0) 27-8-09, near the base. After 100 feet of this we pass into pale-coloured, more nodular, sandy limestones, with hard shaley partings standing out on weathered edges, the whole having suffered much from crushing. This continues for nearly 200 feet with a few obscure traces of cephalopods, especially in bed (1) 3-9-09 which is 80 feet below the well-marked horizon of (1) 27-8-09 which will be used for reference as a datum line, and a number of black lumps which represent cephalopods, at a position 15 to 20 feet below the same horizon. Between the two the nodular grey limestone continues as before until about 5 feet below (1) 27-8-09 when a gradual change sets in and the rock becomes of dark red and neutral colours, and of an earthy, lumpy, calcareous and sandy nature, very tough under the hammer and containing a rich fauna. During this 5 feet we pass through cephalopod horizons (2) 3-9-09 and (3) 3-9-09, and finally arrive at (1) 27-8-09, a rather slabby, hard representative of the dark-red, earthy limestone, a foot or so thick, and especially full of *Gymnites*. It stands out prominently on the outline of the hill. This is followed by 20 feet of black shales and then by horizon (2) 27-8-09 which very nearly repeats the characteristics of bed (1) 27-8-09, but it is not quite so red in colour. We are now near the top of the outlying hill-spur, the rest of the way to the rounded summit being through strata which gradually become more shaley again, and of a drab colour. These continue to the little gap before-mentioned, a thickness of about 400 feet, within which are some fossil horizons, as indicated by a few specimens picked up on the slopes and which are marked (1) and (2) 30-8-09, but have not been otherwise located. Horizon (1) 12-9-09, found on an adjacent spur, is about 50—100 feet above; (2) 27-8-09 must come somewhere about these horizons.

We have now probably passed out of the Muschelkalk and have arrived among the lamellibranch horizons of the Upper Trias marked

(3)—(7) 30-8-09. They all occur in a set of alternating grey or drab limestones and shales, the calcareous layers increasing as we ascend until the rock finally becomes altogether a massive limestone in which nothing but obscure traces of lamellibranchs can occasionally be detected.

In the above section the petrological characters of the rock elements down from the *Gymnites* layers, (1) and (2) 27-8-09, to the base of the nodular limestone, have a great resemblance to the Kumaun and Garhwal sections, a resemblance which is also carried out in their fossil content. But upwards from that datum line the lamellibranch beds (3)—(7) 30-8-09 present us with thick stratigraphical units which are quite unlike those of the Kumaun and Spiti sections, there being no Upper Trias ammonites represented, and also none of the very characteristic *Daonella* shales or *Halobia* limestones.

The fossil contents of the various horizons in the above section from below upwards, as provisionally determined are as follows :—

From horizon (0) 27-8-09, *Pseudomonotis* sp. A thin bed full of them.

From (1) 3-9-09 and another bed 20 feet below (1) 27-8-09 some indeterminate fragments of ammonites.

From (2) 3-9-09 the genera *Ceratites*, *Sturia*?, *Acrochordiceras*, *Orthoceras*, *Meekoceras* in large numbers, and a few lamellibranchs.

From (3) 3-9-09 *Ceratites* sp., *Acrochordiceras*, *Gymnites* sp., *Meekoceras* sp. in large numbers, *Ceratites* (*nodosi* group), *Orthoceras*, *Nautilus* and a large lamellibranch. It should be noted that the last two horizons are not sharply distinguished from (1) 27-8-09 above, and for practical purposes may be considered as one bed with it, 5 feet thick, of which (1) 27-8-09 constitutes the uppermost layer.

From (1) 27-8-09, which is by far the most richly fossiliferous, many examples of *Ceratites Thuillieri*, Opp., one or two of *C. Himalayanus*, Blan., *Hollandites* cf. *Voiti* or *Ravanu*, Dien., *Ceratites* cf. *Airavata*, Dien., *Ceratites* sp., a few examples of the genera *Proarcestes* and *Acrochordiceras*, one *Danubites*, one small *Ptychites*, many *Meekoceras*, a large number of undetermined fragments of ammonites, several fine examples of *Gymnites Jollyanus*, Opp., and many of *Buddhaites Rama*, Dien., also *Gymnites* cf. *Sankara*, Dien., and a large number of undetermined species of *Gymnites*, many *Orthoceras* and *Nautilus*, a few undetermined lamellibranchs, *Athyris* sp. and a few gastropods.

From (2) 27-8-09, many *Hollandites* sp., *Ceratites* sp., one fragment of *Gymnites*, *Acrochordiceras* and *Orthoceras*.

(Above this point in the section no more cephalopods appear actually *in situ*, though one or two specimens were picked up some hundreds of feet above (2) 27-8-09. It thus appears that the well-marked *Ptychites* horizon of other sections presently to be described is either absent here or has eluded observation.)

From horizons (1) and (2) 30-8-09, not found actually *in situ*, and at a level of some 200 feet above (1) 27-8-09, were obtained some fragments of coarsely ribbed *Ceratites* and some gastropods; whilst from (1) 12-9-09 at about this horizon or a little lower on a spur further to the west, a large number of *Rhynchonella* sp. and some ammonite fragments.

Near the marked gap on the ridge (continuing the original section), but rather down the slopes towards the east, from horizon (3) 30-8-09, which is about 400 feet above (1) 27-8-09, a large number of sometimes beautifully preserved specimens of a small *Avicula* ? or *Pecten*.

From (4) 30-8-09, which is 30 feet above (3)—, larger forms of somewhat similar lamellibranchs, *Avicula* or *Pseudomonotis*, together with many *Myophoria* and a few other undetermined lamellibranchs.

Similar forms are found in bed (5) 30-8-09, twenty feet above (4)—, and in beds (6) and (7)—, about 200 feet above (3) and (4)—. In bed (6) also occur a few brachiopods, *Athyris* sp.

From this provisional list of fossils it may now be accepted as proved that a fairly rich and typical upper Muschelkalk, and with probably some Upper Trias fauna, is present in Kashmir in addition to the Lower Trias already proved. The identification and tracing of these well characterised horizons adds considerably to the geological record in this part of the Himalaya and brings Kashmir into line with Spiti, Garhwal and Kumaun. Here, however, as in the other sections presently to be described, there is no trace of a Lower Muschelkalk fauna, as particularly exemplified by the genus *Monophyllites*, the characteristic group of *Ceratites subrobusti* (*Keyserlingites*, Mojs.) and the brachiopod layers with *Rhynchonella Griesbachii*, etc.

But it should be noted that these discoveries were not altogether unanticipated, inasmuch as scattered fragmentary fossil evidence had already shown the practical certainty that a Muschelkalk fauna existed. For instance Lydekker in his general work, page 146, mentions briefly that Stoliczka obtained *Ptychites Gerardi*, Blan., close to the village of Thajwaz [Sind valley?] and says:—"these rocks may therefore be referred to some part of the Trias . . . In Huedes the beds in

which the above-mentioned fossil occurs are referred by Mr. C. L. Griesbach (Rec. Geol. Surv. of India, Vol. XIII, p. 103) to the upper part of the Lower Trias (Muschelkalk)." Also Diener (*Pal. Ind.*, Series XV, Vol. 2, p. 98) mentions that among the collection from Kashmir in the Geological Survey Museum, Calcutta, sent to Vienna for description "there is only one fairly preserved specimen of *Ceratites Thuillieri* from Sunamarg which points to the presence of Muschelkalk." Again Diener (*Pal. Ind.*, Series XV, Vol. V, Mem. 2, p. 138) writes:—"In a letter written shortly before his death A. v. Krafft has drawn my attention to the fact that the Muschelkalk fauna known from Kashmir is not confined to *Ceratites Thuillieri*, Oppel, as stated by me (*loc. cit.* p. 98)." v. Krafft then adds *Gymnites Salteri*, Beyr., from Ladakh (exact locality unknown), and *Proarcestes Balfouri*, Opp., and *Ptychites nov. sp. ind. ex aff. malletiano*, Stol., from localities which there was internal evidence from the labels to show were probably to be found in Kashmir.

(2) *One mile W. of Pastannah.*—For some distance to the west of the section just described in the Muschelkalk and Upper Trias, the lower and more interesting part of the sequence of horizons remains covered by detrital accumulations. On the actual pass leading over to Mandakpal the sections are also obscured by the prevailing forest and deeply soil-covered grassy slopes. But between the two, at a point about one mile W. of Pastannah, a few partial sections may be found on the bridle-road ascending to the pass, and others in the stream-bed in the vicinity. From one of the latter a further collection was made from the *Gymnites* layer, (1) 8-9-09, which is the equivalent of (1) 27-8-09. The section is a steep little undercliff in the bed of the ravine, which may be recognised from Pastannah by the bare rock showing among the vegetation. In the *camera lucida* sketch, Plate 35, it is represented behind and to the right of the Lower Trias horizon, (1) 5-9-09. Here, as in the previous section, the *Gymnites* band forms a prominent steeply dipping ledge of harder rock, whilst both it and the nodular limestone below may be traced to the east slanting across the slopes to cut the bridle-road and making a series of little falls in the water-courses which join the main ravine from the north. These may easily be recognised as they compose a series of graceful precipices dropping down into the forest-covered gorge at their foot.

Owing to slight step-faulting along the face of the crag it was

impossible to make a correct detailed section, and collecting was only attempted from the uppermost *Gymnites* layer.

The following species were obtained from bed (1) 8-9-09 = (1) 27-8-09, some well preserved examples of *Gymnites Jollyanus*, and *G. cf. Jollyanus*, also of *Buddhailes Rama* and *Ceratites Thuillieri*, fragments of *Ceratites* (coarsely ribbed species), one example each of a small species of *Ptychites* and *Proarcestes*, and fragments of *Orthoceras* and *Nautilus* with a few lamellibranchs and gastropods. One very large *Gymnites*, but broken and in a poor state of preservation, had a diameter of $12\frac{1}{2}$ inches, which is somewhat smaller than the specimen mentioned by Diener from Rimkin Paiar (*Pal. Ind.*, Series XV, Vol. 2, part 2, p. 51).

(3) *Khrew, in the Viki plain*—(lat. $34^{\circ} 1'$, long. $75^{\circ} 4'$)—Continuing along the outcrop of the Muschelkalk and Upper Trias over the covered sections on the pass and those on the Mandakpal side of the pass, nothing further was found worthy of detailed exploration until Khrew was reached. The appearance of Muschelkalk at this place proved somewhat of a surprise. During my previous visit to these sections I only just touched the rocks of the Temple hill on my way from Weean to Mandakpal, and did not appreciate the fact that a sharp fold at this place repeated lower beds than the Upper Trias of the Weean spur. Such, however, in 1909 was found to be the case, and a very fine and clear section of the same was brought to light. Thus, in spite of the outcrops of the Permo-Carboniferous trending away from Mandakpal towards W. S. W. and then S. to the spur 2 miles N. of Barus (see plan, Rec. Geol. Surv. of India, Vol. XXXVII, pl. 31), a small irregularity of folding (quite simple but impossible to describe without detailed plans) makes a tiny outcrop of the Muschelkalk reappear in the hills N. W. of Khrew where previously only Upper Trias had been surmised to be present. In general structure and configuration the spur containing this Muschelkalk formation bears a strong likeness to the spur north of Pastannah, both in the way the particular beds occur and the relative position of the gaps on the ridge-crest.

The lowermost beds in this section are exposed on the W. S. W. face of the temple hill, quite close to Khrew town. They appear in the core of a normal anticlinal fold, and consist of lower barren limestones, about 150 feet thick, followed by about 100 feet of limestone and calcareous sandy shale which sheet the lower end of the spur on which the temple stands (see sketch, Pl. 37). Then follow about 80 feet of pale nodular limestone, the equivalent of the nodular limestone at Pastannah

hill. These in turn merge into about 20 feet of reddish calcareous shaley sandstone, (2) 17-9-09, which exactly reproduces the similar reddish rock of the *Gymnites* layer, (1) 27-8-09, in the Pastannah hill section, and like it is separated by some dark shales from an upper *Gymnites* bed, (1) 17-9-09, which outcrops on the very summit of the temple hill, and is the equivalent of (2) 27-8-09. This well-recognisable horizon will again be used here as a datum line from which to reckon the position of any of the succeeding beds and fossil horizons. Its paler lower beds have abundant traces of fossils present as black lumps in the matrix, but nothing good can be extracted except here and there.

From (1) and (2) 17-9-09 was collected a fauna very similar to that of the Pastannah *Gymnites* bed, but much less good, including *Gymnites* sp., *Ceratites Thuillieri*, and other *Ceratites*, *Proarcestes*, *Meekoceras*, *Nautilus*, etc. (This and the succeeding rock stages and fossil horizons are well illustrated in camera sketch, Pl. 37, which is also sufficiently detailed to serve as a section through the series here.)

Above these two horizons from the summit of the temple hill the rock becomes more shaley again, but with calcareous and sandy layers down into the first gap on the ridge and across it to the summit of the prominent little hill (bearing N. 15° W. from Khrew and represented in the camera sketch) a thickness of 350 feet up to beds (4) and (3) 15-9-09. The strata here at the surface are dipping about 40° E. N. E. and they consist of dark crumbling sandy and micaceous shales, with harder bands of tough shaley limestone, the whole being roughly but persistently cleaved.

Bed (4) 15-9-09 consists of these crumbling shales and is full of small brachiopods, chiefly *Rhynchonella* cf. *trinodosi*, Bittn., of which some hundreds were easily collected on the bare weathered surfaces and dipslopes. *Spiriferina* cf. *Griesbacki* or *Haueri* is also present. From (3) 15-9-09, a more hardened layer outcropping at the little summit, were extracted *Ceratites Thuillieri*, *Gymnites* sp. and three other undetermined ammonites.

Half way between the little summit and the next gap to the north at (2½) 15-9-09 which is 125 feet above (3)—, a single example of *Ceratites Thuillieri* was found in similar crumbling shales. At 125 feet higher the little gap is crossed, similar beds continuing, and we then ascend for 35 feet more in the section (which is now beginning to be more calcareous) to bed (2) 16-9-09 which is remarkable for large numbers of lamelli-branches chiefly *Pseudomonotis* sp. with *Myophoria* and some other

undetermined genera, together with several examples of *Buddhaites Rama*, *Gymnites* sp., *Orthoceras*, *Nautilus*, one small *Ptychites* and one large one (? *Megalodisci* group) and one *Ceratites Thuillieri* (?). The presence of the genus *Ptychites* introduces us to a new cephalopod zone, which, however, is much better developed in the Khummu section (see p. 252).

Generally in this bed as in much of the crumbling shales altered by cleavage, fossils are poorly preserved and difficult to find and extract. Dim traces of what were such are seen occasionally on breaking the rock but a good specimen is only found where differential weathering has operated. Even then the ammonites are extremely rare, having only a scattered distribution and demanding arduous search with pick and crowbar.

Above the last horizon, which corresponds to somewhere near horizon (3) 30-S-09 of the Pastannah section, cephalopods entirely cease, the rock becomes gradually more calcareous and we are presumably in the Upper Trias.

About 150 feet above (2) 16-9-09 comes bed (3) 16-9-09, a thin zone amongst the prevailing massive limestone and containing a few examples of *Spiriferina* cf. *Haueri*, Suess., one *Rhyuchonella* sp. and another brachiopod.

Beyond this again, following the spurs round to the north of Khrew, nothing but massive limestone with a few shaley layers occur. They build majestic cliffs, the scarped faces of which are absolutely bare and show the dip planes inclined at 30° — 40° E. N. E. At $\frac{1}{4}$ — $\frac{1}{2}$ mile beyond the spur N. W. of Khrew a few bands occur of ochre-weathering limestone (1) 15-9-09 containing a small *Spiriferina* cf. *Stracheyi*; dip N.E. by E. at 42° . A similar bed (2) 15-9-09 a few hundred yards further on contains an identical fauna. All these beds remind one of those above the *Spiriferina* cf. *Haueri* horizon of the Monastery Hill near Arapal and Lám in the Patarkul valley.

Beyond this point to Bathán, a horizontal distance of about 2 miles the same, generally clear, blue-grey, compact limestone continues in one unbroken outcrop dipping at about 40° with the exception of some quartzites about the position of the "S" of the word Satlupukrin on the Atlas of India sheet. Once more beyond this due east to Zantrag at the next valley head, the same rocks continue, but beyond this they become bent into a series of synclinal troughs, generally more or less reversed or with more steepening dips to the S.W. than to the N. E. up to and including

the high peak at the junction of the ridges S. by E. of Tamnag Station where we seem to be somewhere near the central axis of the syncline as a whole and in the highest beds of this mighty limestone formation. Throughout all this enormous thickness the rock appears to be absolutely barren of organic remains.

Returning for a moment to the Khrew spur section, we find the strike bending round rapidly but steadily to the west, W. S. W. and S. W., until at the S. E. foot of the Weean spur the lowermost beds of the Upper Trias with *Spiriferina* cf. *Stracheyi*, (1) 14-8-08 (last year's number), make their appearance dipping to the N. W. Thus the detrital material and alluvium of the valley between the Khrew spur and the Weean spur hide all continuation of the Muschelkalk in this direction.

(4) *Spur 2 miles N. of Barns.*—In addition to the Upper Trias of the isolated hill at the end of this spur and the dip slope of presumably Lower Trias described in my last paper (*loc. cit.* pp. 314—316) I may now add that on again visiting it in 1909 I came upon reddish calcareous earthy sandstones, feebly exposed in the hollow between the spur and the isolated hill which exactly reproduce the rock of horizons (1) 27-8-09 and (2) 17-9-09, namely, the *Gymnites* bed of the Pastannah and Khrew sections. Although no fossils were found in these chance outcrops, I consider the correlation of the bed with the Muschelkalk justified on petrological grounds.

(5) *Khunmu.*—In addition to the account given in my previous paper (*loc. cit.* pp. 304—306) of the Muschelkalk spur N. N. E. of Khunmu, I have to add here the finding during my second visit of a very characteristic *Ptychites* fauna at and about the horizon given as “near (7) 11-8-08.” Several large weathered specimens were first found in the stream-bed to the east of the spur (B) 6-8-08 (see Plate 29 of my previous paper) and, by a careful series of cross traverses up the dip slope of the spur to the point marked “near (7) 11-8-08,” many more were picked up, including some actually *in situ* in the beds associated with the lamellibranch fauna of that bed. It is evident that these very large forms are exceedingly scarce in this horizon, and I do not think they would have been discovered at all but for the good luck of having an extensive dip-slope to search over after denudation had played its part. Occasionally one of these great discs would be found *in situ*, but completely weathered out, and just ready to be launched down the slope by the next heavy rain. The following were collected here:—*Ptychites* (*megalodisci* group, one of which appears identical with *P. Sumitra*, Dien.),

nine specimens, the largest of which has a greatest diameter of 215 mm., *Ptychites* sp. (small forms) 6 specimens, as well as specimens of *Pinacoceras*, *Gymnites*, *Proucestes*, *Ceratites Thuillieri*, and *Nautilus*.

The exact horizon of the above fauna is probably not far from that of the bed (7) 11-S-08, collected from last year. But it is undoubtedly higher than (6) 11-S-08, the brachiopod bed with *Rhynchonella trinodosa*, etc., and which I correlate with the similar bed in the Khrew section.

The particularly rich, red coloured *Gymnites* bed of the Pastannah and Khrew sections is therefore evidently not exposed in these Khunmu outcrops, but must lie buried out of sight in the detrital fans. A search for the same up the ravine to the west between the Muschelkalk spur and the Lower Trias dip slopes was quite unsuccessful.

(5) *Lám neighbourhood*—(for lat. and long. see *ante*).—Returning back along the outcrop of the Trias into the Patarkul valley at Arapal and Lám, we find the structure there to be as represented in the profile view, Plate 38. Almost the same view, but seen in the distance in combination with the Pastannah section, is also roughly outlined in Plate 36 whereby it is made plain that the two exposures are mutually continuous with each other, though partly hidden beneath the covering of Recent deposits in the Patarkul valley. These Lám exposures are, however, not quite so good as those at Pastannah, and the harvest of fossils obtained was proportionately less. The general strike is N. E.—S. W. with dip to the N. W. into the hill.

The lowest beds in the Lám section seen on the spur immediately above the village, and numbered (3) and (4) 28-8-09, have already been mentioned as probably the uppermost portion of the Lower Trias (see p. 243). The beds which follow above these it will be seen from the drawing have been searched by me as they successively appear on the nearer spurs in the direction of the Ziarat (monastery). These various spurs were taken for examination in preference to following the one spur to the summit of the hill because of their accessibility (being more or less along the line of the water channel which supplies the needs of the monastery) and because of the clearer and more diverse exposures which they afforded. Their relative order with regard to each other is sufficiently represented in the sketch (Pl. 38).

Coming above the (?) Lower Trias there is first about 300 feet of the usual dark grey, sandy, shales, slightly micaceous, with roughly lenticular bedding and imperfect E.—W. cleavage, which must represent all the lower part of the Muschelkalk section of Pastannah, Khrew, etc.,

but no fossils were found until horizon (3) 16-S-09 was struck. This and the three succeeding horizons, fairly near to each other up to (4) 16-S-09, are all fossiliferous, containing the usual Upper Muschelkalk forms, including *Ptychites*. They are generally somewhat calcareous layers in the usual shales. The species obtained with their horizons are as follows :

From (3) 16-S-09, which is 300 feet above the (?) Lower Trias, a specimen of *Bulldhaites Rama*, fragments of *Gymnites* sp., several other fragments of undetermined ammonites, and a large number of *Pseudomonotis*, identical as to species and habit in the rock with those from bed (2) 16-9-09 in the Khrew section.

From (3½) 16-S-09 one specimen of *Ptychites* cf. *rugifer*, Opp., and a fragment of a large ammonite.

From (3¾) 16-S-09 *Ceratites* sp., *Orthoceras* and *Pseudomonotis*.

From (3⅝) 16-S-09 *Ceratites* cf. *Thuillieri*, *Ptychites* cf. *Geradi*, some undetermined fragments of ammonites, and *Nautilus*.

From (4) 16-S-09 *Ptychites* sp., *Pseudomonotis* and other obscure lamellibranchs, *Rhynchonella mutabilis*, Stol., *Rh.* sp. and other undetermined brachiopods.

It is clear from the abundance of *Pseudomonotis* and the *Ptychites* that the set of beds, (3)—(4) 16-S-09 might represent the horizons (2) 16-9-09 of the Khrew section and “near (7) 11-S-08” of the Khunnu section, that is the uppermost portion of the Upper Muschelkalk. Like them too, the fossils, especially the cephalopods, are difficult to detect, only appearing here and there in a scattered distribution in their horizons, and generally remaining hidden in a husk or shell of half-weathered rock, from which they can only be extracted with considerable expenditure of energy. But inasmuch as (4) 16-S-09 has also a strong likeness to (1) 12-9-09 and to (3) (4) 15-9-09, it is unsafe to do more than bracket the whole from (3) 16-S-09 to (6) 16-S-09 with the whole of the Pastannah section from (2) 3-9-09 to (5) 30-S-09.

Above this the Upper Trias must be presumed to begin. The examples of *Ptychites* and other cephalopods cease, and the various lamellibranch and brachiopod horizons, especially those with *Spiriferina* cf. *Haueri*, evidently correspond to the similar horizons in the other Upper Trias sections. The rock also gradually becomes much more calcareous and the shaley bands get less and less.

From horizons (5) 16-S-09, which is 200 feet above (4)—, many

lamellibranchs, including *Myophoria* sp., which remind one of the horizon (4) 30-8-09 at Pastannah, and several other forms of undetermined lamellibranchs.

This is followed by other, less good, lamellibranch horizons, which increase in numbers and generally show matted-together remains. For instance from :—

(6) 16-8-09, which is 325 feet above (5) —, and which forms a prominent rocky knob on the ridge, a small *Avicula* (?) in a hard blue-grey limestone.

Then come a few sandy shales and hard thin bands of grit or quartzite, a few feet thick, with limestone bands.

From (1) 20-8-09, a little above (6) 16-8-09 more lamellibranchs in hard pale grey limestone.

From (1) 16-8-09, at about 300 feet above the last, *Spiriferina* cf. *Stracheyi*, Salt., and undetermined lamellibranchs occur in a rich little bed of dark grey and ochre-coloured limestone with a few interstratified shales. There are probably more than one of these beds not far from each other, and they manifestly represent the beds with the same prominent species in the Khrew section.

Above this the limestones gradually become more massive and blue grey, getting clearer above, and with chrome coloured blotches, until about 400 feet above (1) 16-8-09, with *Spiriferina* cf. *Stracheyi* the uniform slope ceases, and the rock stands up, very massive, in an almost vertical wall as prominently seen in the sketch (Pl. 38). These and all the overlying very great thicknesses of limestone are apparently barren of all organic remains.

(6) *Narastán* (for lat. and long. see *ante.*)—Beyond Lám, to the north, the Trias outcrop was only followed by me as far as the Narastán side-valley, which joins with the Patarkul valley higher up the course of the latter. A slight general bending of the strike carries the outcrop of Trias and Perno-Carboniferous almost due north from Lám across the intervening ridge. Exposures with fossils are poor. Whilst doubtful representatives of the Lower Trias occur as already described at Narastán, somewhere just below that village the Muschelkalk must be hidden by the boulder-strewn bed of a feeder of the Narastán side-valley which comes down from the north.

In the Upper Trias which is well displayed in the rocky spurs to the west of this point the first bed of limestone seen yielded horizon (1) 25-8-09 with *Spiriferina* cf. *Haueri*. A little further west

still, and about one mile from Narastán in the bay of the hills, (2) 25-8-09, with a solitary example of a *Nautilus*, whilst still a little further on comes (3) 25-8-09 with more *Spiriferina* cf. *Haueri* and near it the crinoid limestones (4) and (5) 25-8-09.

In the annexed table are shown at a glance all the fossil horizons, from Silurian to Upper Trias, which have so far been discovered by me during the two seasons spent in Kashmir. They are arranged in order of age. By following the columns down vertically in any locality compartment, one passes successively through older and older beds. On the other hand, all the zone numbers found in one horizontal line are supposed to be of the same age. In case of doubt about any particular fossil zone, brackets have been used to show how much of one group as a whole corresponds to how much of another. In these cases the particular horizons may or may not correspond to each other, the evidence being generally inconclusive on this point.

TABLE OF CORRELATED HORIZONS.

Muschelkalk and Upper Trias.

Horizon of	K. of Geryul ravine, Khutmu.	Khrew.	Weean.	Pastannah.	Lám.	Narastán.	Mandlak-pál.
<i>Spiriferina</i> cf. <i>Haueri</i> , <i>S. Strocheyi</i> and lamelli-branches.	{ (4) 8-8-08 (3) Do. (2) Do. (1) Do. }	{ (2) 15-9-09 (1) Do. (3) 16-9-09 }	{ (1) 14-8-05 }	—	{ (1) 16-8-09 (1) 20-8-09 }	{ (3) 25 8-09 (2) Do. (1) Do. }	—
<i>Ptychites</i> (<i>Megalodisci</i> group) and. <i>Pseudomonotis</i> .	{ (7) 11-8-09 and near (7) 11-8-09 }	(2) 16-9-09	—	{ (7) 30-8-09 (6) Do. (5) Do. (4) Do. (3) Do. }	—	—	—
<i>Ceratites</i> sp.	—	(2½) 16-9-09	—	{ (2) 30-8-09 (1) Do. }	{ (6) 16-8-09 (5) Do. (4) Do. (3½) Do. (3) Do. (3½) Do. (3) Do. }	—	—
<i>Rhynchonella trinodosa</i> and <i>R.</i> sp.	(6) 11-8-08	{ (3) 15-9-09 (4) Do. }	—	(1) 12-9-09	—	—	—
<i>Gymnites</i> and <i>Ceratites</i> , etc.	—	{ (1) 17-9-09 (2) Do. }	—	{ (2) 27-8-09 (1) 8-9-09 and (1) 27-8-09 (3) 3-9-09 (2) Do. }	—	—	—
—	—	—	—	{ (1) 8-9-09 (0) 27-8-09 }	—	—	—

TABLE OF CORRELATED HORIZONS—*contd.*
Lower Trias.

Horizon of	E. of Guryul ravine, Khumu.	Khrew.	Weean.	Pastannah.	Lám.	Narastán.	Mandak- pál.
<i>Pseudomonotis</i> , etc.	—	—	—	—	{ (4) 20-8-09 (3) Do. }	—	—
<i>Hungarites</i> (posi- tion uncertain).	—	—	—	(x) 4-9-09	—	—	—
<i>Meckoceras</i>	{ (4) 6-8-03 (3) Do. (2) Do. (1) Do. }	—	—	—	—	(?) (2) 23-8-09.	{ (4) 14-8-08. (3) Do.
<i>Ophicerus</i>	—	—	—	(1) 5-9-09	—	—	—

Zéwan or Permo-Carboniferous.

—	Golagharh Pass.	Barus.	2 miles N. of Barus.	Mandakpál.	Guryul Ravine.	Pastannah.	Lám and Narastán.
<i>Lamellibranchs</i>	—	—	{ (3) 26-8-08 (4) Do. }	—	—	—	—
<i>Spirifer Rajah</i> (predominant).	C	(1) 23-8-08	Present (no number).	(1) 2-10-09	—	(1) 11-9-09	—
—	—	—	—	(2) 2-10-09	—	—	—
<i>Spirifer Rajah</i> , <i>Marginites</i> , <i>Productus Cora</i> , <i>Lytania</i> , etc.	B	—	(5) 26-8-08	(3) 14-9-08	—	—	—
<i>Productus semi- reticulatus</i> .	—	—	—	—	(1) 10-10-09	—	(1) 23-8-09
—	—	—	—	{ (1) 16-8-08 (2) Do. }	{ (1) 2-8-08	—	—
<i>Protoreleporus ampla</i> .	Z. 2.	Present.	Present.	Present.	Present.	Absent.	Absent.
—	Z. 1.	{ (3) 26-8-08 (2) Do. (1) Do. }	—	—	(1) 4-8-08	—	—

TABLE OF CORRELATED HORIZONS—*contd.*

Lower Gondwana.

Horizon.	Golabgarh Pass.	Pansapurn.	Vili district.
<i>Glossopteris</i> and <i>Verlebraria</i>	X	} (P) (1) 9-8-09	—
<i>Gangamopteris</i> and <i>Psymphyllum</i> .	W. 1.		Present at Bishu and Zéwan spurs.

Panjal Traps and Agglomeratic Slate (Unfossiliferous).

Fenestella Series (Middle Carboniferous?).

Horizon.	Lehindajjar.	Left bank Lidar R. S. S. E. of Dowhat.	Head of Kirraun valley.	Burn.
Uppermost Fenestella bed	(3) 27-5-09	(1) 1-6-09	—	—
"Camp" horizon	{ (1) 26-5-09 (2) 23-5-09 }	{ (2) 13-9-08 (3) Do. (5) Do. (4) Do. (1) 6-9-08 (1) 6-6-09 }	(1) 8-8-09	(1) 13-5-09
Lehindajjar bed	{ (3) 24-5-09 (2) Do. }			

Passage Beds.

Syringothyris Limestone Series (Lower Carboniferous).

—	Kotsu.	Eishmakām and neighbourhood.	N. W. of Pusan.
—	{ (2) 15-5-09 (2) 12-5-09 }	{ (0) 3-9-08 (2) 3-9-08, (4) 5-9-08, (1) 14-6-09 (3) Do. (3) Do. (2) Do. (3) Do. }	(1) 27-6-09 { (1) 4-7-09 (2) Do.

TABLE OF CORRELATED HORIZONS—*concl'd.*

"Muth" Quartzite.

Upper Silurian.				
—	Gugaldar.	Gudramer.	Margan Pass S. side.	Lutherwan.
—	(1) 19-6-09	(1) 11-7-09	(1) 21-7-09	(1) 22-7-09

In conclusion, I should like to draw attention to the fine field which Kashmir offers to future explorers among Himalayan fossiliferous sedimentaries. In the vale of Kashmir, or within a few easy marches from the capital of the State, there are deposits of Silurian, Carboniferous and Trias age, comparable in many respects to those which occur in the classic regions of the Salt Range, Spiti, Garhwal and Kumaun. The last three places are, however, some weeks of arduous marches from railway and road, are only accessible with difficulty, and lie at elevations sometimes twice or even thrice that of the Kashmir areas. The Salt Range on the other hand lies at a low elevation, and cannot compare in climate with Kashmir, which also, as is well-known, is an ideal embodiment of the picturesque and beautiful.

There is only one drawback, and that is that one must dig, and dig very laboriously and continuously, before one obtains worthy representatives of the rich faunas that for so long have lain almost neglected.

REFERENCES.

1888. R. D. Oldham . Sequence and correlation of the Pre-Tertiary sedimentary formations of the Simla region. *Records, Geol. Surv. India*, Vol. XXI, pt. 3.
- " " . Geology of the North-West Himalayas, *Records*, XXI, pt. 4.
1891. C. L. Griesbach . Geology of the Central Himalayas. *Memoirs*, Vol. XXIII.
1893. " . Notes on the Central Himalayas, *Records*, Vol. XXVI, pt. 1.
1896. C. S. Middlemiss . Geology of Hazara, *Memoirs*, Vol. XXVI.
1898. C. Diener . Notes on the Geological structure of the Chitichun region, *Memoirs*, Vol. XXVIII, pt. 1.
1902. A. von Krafft . Exotic Blocks of Malla Johar, Kumaun, *Memoirs*, Vol. XXXII, pt. 3.

- 1904 H. H. Hayden . Geology of Spiti, *Memoirs*, Vol. XXXVI, pt. 1.
 „ R. D. Oldham . Zéwan beds in the Vihi District, Kashmir, *Records*, Vol. XXXI, pt. 1.
1905. C. Diener . The Triassic fauna of the *Tropites* limestone of Byans, *Records*, Vol. XXXII, pt. 3.
1906. „ . Notes on some Fossils from the *Halorites* limestone of the Bambanag cliff, Kumaun, *Records*, Vol. XXXIV, pt. 1.
- 1907 } H. H. Hayden . Stratigraphical position of the *Gangamopteris* beds of
 1908 } Kashmir, *Records*, Vol. XXXVI, pt. 1.
 „ A. C. Seward . Permo-Carboniferous Plants from Kashmir, *Records* Vol. XXXVI, pt. 1.
- 1908 } T. H. Holland . Occurrence of striated boulders in the Blaini formation
 1909 } of Simla, *Records*, Vol. XXXVII, pt. 1.
 „ S. G. Burrard and A sketch of the Geography and Geology of the Hima-
 H. H. Hayden. layan Mountains and Tibet, pt. 4.
 „ C. S. Middlemiss . Gondwanas and related marine sedimentary series of
 Kashmir, *Records*, Vol. XXXVII, pt. 4.
- also *Palæontologia Indica*, Series XV, Himalayan Fossils, Vols. I, II, III, IV, V, VI, chiefly by C. Diener, but also by E. von Mojsisovics, A. Bittner, V. Uhlig, F. R. C. Reed and A. von Krafft, and New Series Vol. II, Mem. 2, by A. C. Seward and A. Smith Woodward.

LIST OF PLATES.

- Plate 28. Panjal bedded traps, N. E. of Gugaldar.
- „ 29, fig. 1. Section, Lidar Valley (after Lydekker).
 „ „ „ 2. Lidar Valley anticline.
- „ 30. „ 1. General section, N. E. of Martand.
 „ „ „ 2. General section, Naubug Valley, Margán pass and Wardwán.
- „ 31. „ 1. Fenestella series, Lehindajjar.
 „ „ „ 2. Part of Fenestella series, left bank of Lidar river, S. S. E. of Dowhat.
- „ 32. Section in Trias near Pastannah.
 „ 33. View N. E. from near Eishmakám.
 „ 34. View of Kotsu Hill from N. W.
 „ 35. View S. W. towards pass from hill-spur N. N. W. of Pastannah.
- „ 36. View N. N. E. from one mile west of Pastannah.
 „ 37. View N. W. from Khrew.
 „ 38. View N. E. from Arapal camping-ground.
 „ 39. Map of Silurian-Trias sequence.

NOTE ON THE DISCOVERY BY MR. MIDDLEMISS OF
FENESTELLA-BEARING BEDS IN KASHMIR. BY H. H.
HAYDEN, *Superintendent, Geological Survey of India.*

OF the many important discoveries made in recent years in Kashmir, those recorded by Mr. Middlemiss in the foregoing paper will probably prove to be the most far-reaching, since they throw a new light on what has been the most vexed question in the whole realm of Indian geology, the great Gondwana controversy, and may possibly compel us to revise our estimate of the age of the Talehir boulder-bed and of the fossiliferous horizons immediately overlying it. The object of the present note, however, is not to discuss the general bearings of the recent discoveries—a task which will no doubt be ably carried out by Mr. Middlemiss in due course —, but to draw attention to, and to correct, certain misapprehensions of my own.

The part of Mr. Middlemiss' paper which has an immediate bearing on the case is that comprised in pages 222 to 232, from which it will be seen that he has definitely proved the presence in several localities of certain beds containing *Fenestella*, and which he categorically identifies with the *Fenestella* shales of Spiti. In a paper published in 1904,¹ and in subsequent papers,² I have correlated the Spiti *Fenestella* Shales with the lower beds of the Zéwan stage, which are separated from Mr. Middlemiss' *Fenestella* beds by the whole thickness of the agglomeratic slate and the Panjal trap. This correlation was based on a description by Professor Diener³ of certain fossils supposed to have been collected in beds of the Zéwan stage, but Mr. Middlemiss⁴ has now shown that these fossils were a mixed lot derived partly from his *Fenestella* beds and partly from the true Zéwan stage and he has made out a very strong case for the correlation of the *Fenestella* shales of Spiti with the *Fenestella* beds of Kashmir. If this is correct, we have now to

¹ *Mem., Geol. Surv. India*, XXXVI, part i (1904).

² *Rec., Geol. Surv. India*, XXXVI, 35 (1907); Burrard and Hayden: *Geography and Geology of the Himalaya and Tibet*, 244 (1908).

³ *Pal. Indica*, Sec. XV, Vol. I, pt. 2.

⁴ *Mem., Geol. Surv. India*, XXXVI, pt. 149 (1904).

look, in Spiti, for the equivalent of the lower part of the Zéwan stage with *Protoretepora ampla*. It is of course possible that there are two *Fenestella* horizons in Spiti, as indeed at first sight there appear to be on the left side of the Spiti river below Po, but on the whole the evidence is against this. The *Productus* shales of Spiti may be safely correlated with the similar beds of Kashmir, but we ought properly to restrict this term to the beds containing *Marginifera* and *Spirifer rajah*; the lower part of the Zéwan stage with *Protoretepora ampla* must then find its equivalent in Spiti either in the Calcareous sandstone stage or in the underlying conglomerate, or in both. One is certainly tempted to see in the great unconformity, which extends from Kumaun to Spiti, the equivalent of the break in continuity of marine sedimentation represented by the Panjal trap, in which case the Spiti conglomerate will after all approximate in age to the Talchir boulder-bed. And here I must cry "*peccavi*" in having dissented so emphatically from Mr. Oldham's correlation of these one with the other, and in fairness to him I must admit, with equal emphasis, that not only has the supposed evidence against this broken down but the new facts collected by Mr. Middlemiss are decidedly in its favour. This, however, refers only to the correlation of the Spiti conglomerate with the Talchir boulder-bed and that only from the point of view of homotaxis, not of mode of origin, for I still regard the Spiti rock as an ordinary conglomerate and quite distinct from a tillite; nor does this affect my views as to the age and relationships of the Blaini boulder-slate.¹

In the light of Mr. Middlemiss' discoveries further study of the Po series of Spiti is highly desirable. It was only very cursorily examined by the late Dr. von Krafft and myself and may comprise fossiliferous horizons not yet found. So far *Protoretepora ampla* has only been observed in the *Fenestella* shales of Losar, but the persistence of this species in Kashmir as exemplified by its survival from the *Fenestella* beds up to the Zéwan stage, that is to say through a postulated glacial epoch² followed by one of undoubted volcanic activity is very striking. This can only be explained either by great hardness

¹ Burrard and Hayden: *op. cit.* p. 228 (1908).

² Recent work has not adduced any evidence in favour of a glacial origin for the agglomeratic slate (Panjal conglomerate), which Mr. Middlemiss is evidently inclined to regard rather as of volcanic origin.

HAYDEN: *Fenestella* Beds in Kashmir.

and stability of the species or else by re-immigration at the close of the volcanic period. The recurrence of this species, as well as that of one or more species of *Productus*, rather indicates that the Panjal volcanic period was of comparatively short duration, in spite of the great thickness of material poured out. In this case there may have been no great time-interval between the deposition of the *Fenestella* beds and that of the lowest beds of the Zéwan stage. We must look to Mr. Middlemiss for an answer to this question which has an important bearing on the age of the Talchir stage.



C.S. Middlemiss, Photo.

PANJAL BEDDED TRAPS, N.E. OF GUGALDAR

G. S. I. Calcutta.

GEOLOGICAL

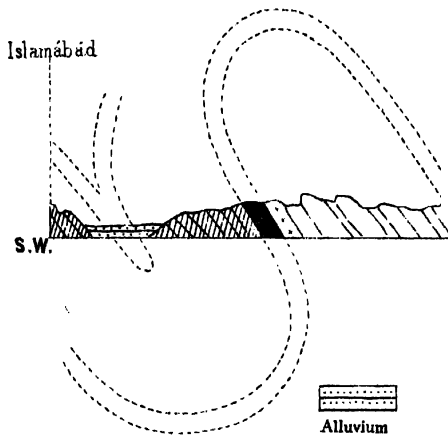


FIG. 1. SEC

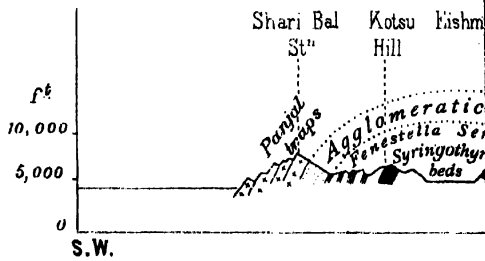


FIG. 2. LIDAR V

RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

VOL. XXXVIII, PART 4.

1910.

CONTENTS.

	PAGES
Geology and Prospects of Oil in Western Prome and Kama, Lower Burma (including Namayan, Padaung, Taungbogyl, and Zialing). By Murray Stuart, B.Sc., F.G.S., Assistant Superintendent, Geological Survey of India. (With Plate 23)	259-270
The Recorrelation of the Pegu system in Burma with notes on the Horizon of the Oil-bearing strata (including the Geology of Padaukpin, Banbyin, and Aukma-neln). By Murray Stuart, B.Sc., F.G.S., Assistant Superintendent, Geological Survey of India. (With Plate 24)	271-291
Fossil Fish Teeth from the Pegu System, Burma. By Murray Stuart, B.Sc., F.G.S., Geological Survey of India. (With Plates 25 to 27)	292-301
The Northern Part of the Yenangyat Oilfield. By G. de P. Cotter, B.A. (Dub.), F.G.S., Assistant Superintendent, Geological Survey of India. (With Plates 28, 29 and 29a)	302-307
On some Iron Ores of Chanda, Central Provinces. By P. N. Datta, B.Sc., Assistant Superintendent, Geological Survey of India	308-312
The Geology of the Aden Hinterland. By Captain R. E. Lloyd, M.B., D.Sc., I.M.S., late Surgeon-Naturalist, Marine Survey of India. (With Plates 30 to 33)	313-320
Petrological Notes on the Rocks collected by Captain R. E. Lloyd, near Aden. By E. W. Vredenburg, A.R.S.M., A.R.C.S., F.G.S., etc., Assistant Superintendent, Geological Survey of India. (With Plate 34)	321-335
Notes on Upper Jurassic Fossils collected by Captain R. E. Lloyd, near Aden. By G. H. Tipper, M.A., F.G.S., Assistant Superintendent, Geological Survey of India. (With Plates 35 and 36)	336-340
Miscellaneous Notes: Samarskite in South India	342
Index	i-xxx

Published by order of the Government of India

CALCUTTA:

SOLD AT THE OFFICE OF THE GEOLOGICAL SURVEY,
27, CHOWRINGHEE ROAD.

LONDON: MESSRS. KEGAN PAUL, TRENCH TRÜBNER & CO
BERLIN: MESSRS. FRIEDLÄNDER UND SOHN.

1910

Price One Rupee per Part, or Two Rupees per Volume of 4 Parts

MEMOIRS OF THE GEOLOGICAL SURVEY OF INDIA.

- VOL.** I. Pt. 1, 1856 (*out of print*) : Coal and Iron of Talchir.—Talchir Coal-field.—Gold-yielding deposits of Upper Assam.—Gold from Shuë-gween. Pt. 2, 1858 (*out of print*) : Geological structure of a portion of Khasi Hills.—Geological structure of Nilgiri Hills (Madras). Pt. 3, 1859 (*out of print*) : Geological structure and physical features of districts of Bankura, Midnapore, and Orissa.—Laterite of Orissa.—Fossil fish-teeth of genus *Ceratodus*, from Maledi, south of Nagpur.
- VOL.** II. Pt. 1, 1860 (*out of print*) : Vindhyan rocks, and their associates in Bundelkand. Pt. 2, 1860 (*out of print*) : Geological structure of central portion of Nerbudda District.—Tertiary and alluvial deposits of central portion of Nerbudda Valley.—Geological relations and probable age of systems of rocks in Central India and Bengal.
- VOL.** III. Pt. 1, 1863 (*out of print*) : Raniganj Coal-field.—Additional remarks on systems of rocks in Central India and Bengal.—Indian Mineral Statistics, I. Coal. Pt. 2, 1864 (*out of print*) : Sub-Himalayan Ranges between Ganges and Ravi.
- VOL.** IV. Pt. 1, 1863 (*out of print*) : Cretaceous Rocks of Trichinopoly District, Madras. Pt. 2, 1864 (*out of print*) : Districts of Trichinopoly, Salem, etc. Pt. 3, 1865 (*out of print*) : Coal of Assam, etc.
- VOL.** V. Pt. 1, 1865 (*out of print*) : Sections across N W Himalaya, from Sutlej to Indus.—Gypsum of Spiti. Pt. 2, 1866 (*out of print*) : Geology of Bombay. Pt. 3, 1866 (*out of print*) : Jheria Coal-field.—Geological Observations on Western Tibet.
- VOL.** VI. Pt. 1, 1867 (*out of print*) : Neighbourhood of Lynyan, etc., in Sind.—Geology of portion of Cutch. Pt. 2, 1867, Rep. 1908 (*price* 2 Rs.). Bokaro Coal field—Ramgath Coal-field—Traps of Western and Central India. Pt. 3, 1869 (*price* 2 Rs. 8 As.) : Tapti and Nerbudda Valleys.—Frog-beds in Bombay.—*Oxyglossus pusillus*.
- VOL.** VII. Pt. 1, 1869 (*price* 3 Rs.) : Vindhyan series.—Mineral Statistics.—Coal.—Shillong Plateau. Pt. 2, 1870 (*out of print*) : Karharbári Coal-field.—Deoghar Coal-field. Pt. 3, 1871 (*out of print*) : Aden water-supply.—Káranpura Coal-fields.
- VOL.** VIII. Pt. 1, 1872 (*price* 4 Rs.) : Kadapah and Karnul Formations in Madras Presidency. Pt. 2, 1872 (*price* 1 Rs.) : Itkhuri Coal-field.—Daltonganj Coal-field.—Chope Coal field.
- VOL.** IX. Pt. 1, 1872 (*price* 4 Rs.) : Geology of Kutch. Pt. 2, 1872 (*price* 1 Rs.) : Geology of Nagpur.—Geology of Sirhan Hill.—Carboniferous Ammonites.
- VOL.** X. Pt. 1 (*price* 3 Rs.) : Geology of Madras.—Sátpura Coal-basin. Pt. 2, 1874 (*price* 2 Rs.) : Geology of Pegu.
- VOL.** XI. Pt. 1, 1874 (*price* 2 Rs.) : Geology of Dárajiling and Western Duars. Pt. 2, 1876 (*price* 3 Rs.) : Salt-region of Kohát, Trans-Indus.
- VOL.** XII. Pt. 1, 1877 (*price* 3 Rs.) : South Máhrátá Country. Pt. 2, 1876 (*price* 2 Rs.) : Coal-fields of Nága Hills.
- VOL.** XIII. Pt. 1, 1877 (*price* 2 Rs. 8 As.) : Wardha Valley Coal-field. Pt. 2, 1877 (*price* 2 Rs. 8 As.) : Gtology of Rájmahál Hills.
- VOL.** XIV. 1878 (*price* 5 Rs.) : Geology of Salt-range in Punjab.
- VOL.** XV. Pt. 1, 1878 (*price* 2 Rs. 8 As.) : Anruna and Hutár Coal-fields (Palamow). Pt. 2, 1880 (*price* 2 Rs. 8 As.) : Ramkola and Tatapani Coal-fields (Sirguja).
- VOL.** XVI. Pt. 1, 1879 (*price* 1 Rs. 8 As.) : Geology of Eastern Coast from Lat. 15° to Masulipatam. Pt. 2, 1880 (*price* 1 Rs. 8 As.) : Nellore Portion of Carnatic. Pt. 3, 1880 (*price* 2 Rs.) : Coastal Region of Godávari District.
- VOL.** XVII. Pt. 1, 1879 (*price* 3 Rs.) : Geology of Western Sind. Pt. 2, 1880 (*price* 2 Rs.) : Trans-Indus extension of Punjab Salt-range.

- Vol. XVIII.** Pt. 1, 1881 (*price 2 Rs.*) : Southern Afghanistan. Pt. 2, 1881 (*out of print*) : Mánbhūm and Singhbhūm. Pt. 3, 1881 (*price 2 Rs.*) : Fránhita, Godávari Valley.
- Vol. XIX.** Pt. 1, 1882 (*price 2 Rs.*) : Cachar Earthquake of 1868. Pt. 2, 1882 (*price 1 Rs.*) : Thermal Springs of India. Pt. 3, 1883 (*price 1 Rs.*) : Catalogue of Indian Earthquakes. Pt. 4, 1883 (*out of print*) : Geology of parts of Manipur and Naga Hills.
- Vol. XX.** Pt. 1, 1883 (*out of print*) : Geology of Madura and Tinnevely. Pt. 2, 1883 (*out of print*) : Geological notes on Hills in neighbourhood of Sind and Punjab Frontier between Quetta and Dera Ghasi Khan.
- Vol. XXI.** Pt. 1, 1884 (*out of print*) : Geology of Lower Narbada Valley. Pt. 2, 1884 (*out of print*) : Geology of Kathiawar. Pt. 3, 1885 (*out of print*) : Coal-field of South Rewah. Pt. 4, 1885 (*out of print*) : Barren Island.
- Vol. XXII.** 1883 (*price 5 Rs.*) : Geology of Kashmir, Chamba, and Kagan.
- Vol. XXIII.** 1891 (*price 5 Rs.*) : Geology of Central Himalayas.
- Vol. XXIV.** Pt. 1, 1887 (*out of print*) : Southern Coal-fields of Sápura Gondwána basin. Pt. 2, 1890 (*out of print*) : Geology of Sub-Himalaya of Garhwal and Kumaun. Pt. 3, 1890 (*out of print*) : Geology of South Malabar, between Beypore and Ponnáni Rivers.
- Vol. XXV.** 1896 (*out of print*) : Geology of Bellary District, Madras Presidency.
- Vol. XXVI.** 1896 (*out of print*) : Geology of Hazara.
- Vol. XXVII.** Pt. 1, 1895 (*out of print*) : Marine Fossil from Miocene of Upper Burma. Pt. 2, 1897 (*out of print*) : Petroleum in Burma and its technical exploitation.
- Vol. XXVIII.** Pt. 1, 1898 (*price 2 Rs.*) : Geological Structure of Chittichū region.—Allahbūd in north west of Rann of Kuchh.—Geology of parts of Myingyan, Magwè and Pakokku Districts, Burma.—Geology of Mikir Hills in Assam.—Geology of Tirah and Bazái Valley. Pt. 2, 1900 (*price 3 Rs.*) : Charnockite Series, group of Archaean Hypersthénic Rocks in Peninsular India.
- Vol. XXIX.** 1900 (*price 5 Rs.*) : Earthquakes of 12th June 1897.
- Vol. XXX.** Pt. 1, 1900 (*price 2 Rs.*) : Aftershocks of Great Earthquake of 12th June 1897. Pt. 2, 1900 (*price 1 Rs.*) : Geology of neighbourhood of Salem, Madras Presidency. Pt. 3, 1901 (*price 1 Rs.*) : Sivamalai Series of Elmolite-Syenites and Corundum Syenites. Pt. 4, 1901 (*price 1 Rs.*) : Geological Congress of Paris.
- Vol. XXXI.** Pt. 1, 1901 (*price 2 Rs.*) : Geology of Son Valley in Rewah State and of Parts of Jabalpur and Mirzapur. Pt. 2, 1901 (*price 3 Rs.*) : Baluchistan Desert and part of Eastern Persia. Pt. 3, 1901 (*price 1 Rs.*) : Peridotites, Serpéntines, etc., from Ladakh.
- Vol. XXXII.** Pt. 1, 1901 (*price 1 Rs.*) : Recent Aftesian Experiments in India. Pt. 2, 1901 (*price 2 Rs.*) : Rampur Coal field. Pt. 3, 1902 (*price 3 Rs.*) : "Exotic Blocks" of Malla Johar in Bhot Mahals of Kumaon. Pt. 4, 1904 (*price 3 Rs.*) : Jammu Coal fields.
- Vol. XXXIII.** Pt. 1, 1901 (*price 8 Rs.*) : Kolar Gold field. Pt. 2, 1901 (*price 2 Rs.*) : Art. 1. Gold fields of Wainád. Art. 2. Auriferous Quartzites of Parhadiah, Chota Nagpur. Art. 3. Auriferous localities in North Coimbatore. Pt. 3, 1902 (*price 1 Rs.*) : Geology of Kalahandi State, Central Provinces.
- Vol. XXXIV.** Pt. 1, 1901 (*price 1 Rs.*) : Peculiar form of altered peridotite in Mysore State. Pt. 2, 1902 (*price 3 Rs.*) : Mica deposits of India. Pt. 3, 1903 (*price 1 Rs.*) : Sandhills of Clifton near Karachi. Pt. 4, 1906 (*price 4 Rs.*) : Geology of Persian Gulf and adjoining portions of Persia and Arabia.
- Vol. XXXV.** Pt. 1, 1902 (*price 2 Rs.*) : Geology of Western Rajputana. Pt. 2, 1903 (*price 1 Rs.*) : Aftershocks of Great Earthquake of 12th June 1897. Pt. 3, 1904 (*price 1 Rs.*) : Seismic phenomena in British India and their connection with its Geology. Pt. 4 (*in the Press*) : Geology of Andaman Islands, with references to Nicobars.
- Vol. XXXVI.** Pt. 1, 1904 (*price 4 Rs.*) : Geology of Spiti. Pt. 2, 1907 (*price 3 Rs.*) : Geology of Provinces of Tsing and Ü in Central Tibet. Pt. 3 (*in the Press*) : Trias of the Himalayas.
- Vol. XXXVII.** 1909. Manganese-Ore Deposits of India : Pt. 1 (*price 3 Rs.*) : Introduction and Mineralogy; Pt. 2 (*price 3 Rs.*) : Geology; Pt. 3 (*price 3 Rs.*) : Economics and Mining; Pt. 4 (*price 5 Rs.*) : Description of Deposits.
- Vol. XXXVIII.** 1910 (*price 5 Rs.*) : Kangra Earthquake of 4th April 1905.

PALÆONTOLOGIA INDICA.

(SER. I, III, V, VI, VIII.)—CRETACEOUS FAUNA OF SOUTHERN INDIA, *by*
F. STOLICZKA, *except* Vol. I, Pt. 1, *by* H. F. BLANFORD.

SER. I & III.—Vol. I. The Cephalopoda (1861-65), pp. 216, pls. 84 (6 double).
V.—Vol. II. The Gastropoda (1867-68), pp. xiii, 500, pls. 23.
VI.—Vol. III. The Pelecypoda (1870-71), pp. xxii, 537, pls. 50.
VIII.—Vol. IV. The Brachiopoda, Oiliopoda, Echinodermata, Corals, etc. (1872-73), pp. v, 202, pls. 29.

(SER. II, XI, XII.)—THE FOSSIL FLORA OF THE GONDWANA SYSTEM, *by*
O. FEISTMANTEL, *except* Vol. I, Pt. 1, *by* T. OLDHAM and J. MORRIS.

Vol. I, pp. xviii, 233, pls. 72. 1863-79. Pt. 1; Rájmahál Group, Rájmahál Hills, Pt. 2; *The same (continued)*. Pt. 3; Plants from Golapilli. Pt. 4; Outliers on the Madras Coast.
Vol. II, pp. xli, 115, pls. 26. 1876-78. Pt. 1; Jurassic Flora of Kach. Pt. 2: Flora of the Jabalpur Group.
Vol. III, pp. xi, 64+149, pls. 80 (9 double) (I—XXXI+IA—XLVIIA). 1879-81. Pt. 1; The Flora of the Talchir-Karharbari beds. Pt. 2; The Flora of the Damuda and Panchet Divisions. Pt. 3; *The same (concluded)*.
Vol. IV, pp. xxvi, 25+66, pls. 35 (2 double) (I—XXV+IA—XIVA). Pt. 1 (1882); Fossil Flora of the South Rewah Gondwana basin. Pt. 2 (1886); Fossil Flora of some of the coal-fields in Western Bengal.

(SER. IX.)—JURASSIC FAUNA OF KACH.

Vol. I (1873-76). The Cephalopoda, *by* W. WAAGEN, pp. i, 247, pls. 60 (6 double).
Vol. II, pt. 1 (1893). The Echinoidæ of Kach, *by* J. W. GREGORY, pp. 12, pls. 2.
Vol. II, pt. 2 (1900). The Corals, *by* J. W. GREGORY, pp. 196, I—IX, pls. 26.
Vol. III, pt. 1 (1900). The Brachiopoda, *by* F. L. KITCHIN, pp. 87, pls. 15.
Vol. III, pt. 2 (1903). Lamellihranchiata: Genus Trigonia, *by* F. L. KITCHIN, pp. 122, pls. 10 (*out of print*).

(SER. IV.)—INDIAN PRE-TERTIARY VERTEBRATA.

Vol. I, pp. vi, 137, pls. 26. 1865-85. Pt. 1 (1865); the Vertebrate Fossils from the Panchet rocks, *by* T. H. HUXLEY. Pt. 2 (1878); The Vertebrate Fossils of the Kota-Maleri Group, *by* SIR P. DE M. GREY EGERTON, L. C. MIALL, and W. T. BLANFORD. Pt. 3 (1879); Reptilia and Batrachia, *by* R. LYDEKKER. Pt. 4 (1885); The Labyrinthodont from the Bijori group, *by* R. LYDEKKER (*out of print*). Pt. 5 (1885); The Reptilia and Amphibia of the Maleri and Denwa groups, *by* R. LYDEKKER (*out of print*).

(SER. X.)—INDIAN TERTIARY AND POST-TERTIARY VERTEBRATA, *by*
R. LYDEKKER, *except* Vol. I, Pt. 1, *by* R. B. FOOTE.

Vol. I, pp. xxx, 300, pls. 50. 1874-80. Pt. 1; Rhinoceros deccanensis. Pt. 2; Molar teeth and other remains of Mammalia. Pt. 3; Crania of Ruminants. Pt. 4; Supplement to Pt. 3. Pt. 5; Siwalik and Narbada Proboscidea.
Vol. II, pp. xv, 363, pls. 45. 1881-84. Pt. 1; Siwalik Rhinocerotidae. Pt. 2; Supplement to Siwalik and Narbada Proboscidea. Pt. 3; Siwalik and Narbada Equidae. Pt. 4; Siwalik Camelopardalidae. Pt. 5; Siwalik Selenodont Equina, etc. Pt. 6; Siwalik and Narbada Carnivora.

VOL. III, pp. xxiv, 264, pls. 38. 1894-86. Pt. 1; Additional Siwalik Perissodactyla and Proboscidea. Pt. 2; Siwalik and Narbada Bunodont Suina. Pt. 3; Rodents and new Ruminants from the Siwaliks. Pt. 4; Siwalik Birds. Pt. 5; Mastodon Teeth from Perim Island. Pt. 6; Siwalik and Narbada Chelonia. Pt. 7; Siwalik Crocodilia, Lacertilia and Ophidia. Pt. 8; Tertiary Fishes.

VOL. IV, pt. 1, 1896. Siwalik Mammalia (Supplement 1); pp. 18, pls. 6.

VOL. IV, pt. 2, 1896. The Fauna of the Karnul caves (and addendum to pt. 1); pp. 40 (19-58), pls. 5 (vii-xi).

VOL. IV, pt. 3, 1897. Eocene Chelonia from the Salt-range; pp. 7 (59-65), pls. 2 (xii-xiii).

(SER. VII, XIV.)—TERTIARY AND UPPER CRETACEOUS FAUNA OF WESTERN INDIA, by MARTIN DUNCAN and W. PERCY SLADEN, *except* Pt. 1, by F. STOLICZKA.

VOL. I, pp. 16+110+382+91=599, pls. 5+28+58+13=104. 1871-85. Pt. 1: Tertiary Crabs from Sind and Kach. Pt. 1 (new 2): Sind Fossil Corals and Alcyonaria; by P. Martin Duncan. Pt. 3: The Fossil Echinoidea of Sind: *Fas. 1*, The *Cardita beaumonti* beds; *Fas. 2*, The Ranikot Series in Western Sind; *Fas. 3*, The Khirthar Series; *Fas. 4*, The Nari (Oligocene) Series; *Fas. 5*, the Gaj (Miocene) Series; *Fas. 6*, The Makran (Pliocene) Series; by Duncan and Sladen. Pt. 4: The Fossil Echinoidea of Kach and Kattywar, by Duncan, Sladen and Blanford.

(SER. XIII.)—SALT-RANGE FOSSILS, by WILLIAM WAAGEN, PH.D.

Productus-Limestone Group: Vol. I, pt. 1 (1879). Pisces, Cephalopoda, pp. 72, pls. 6.

" " " " 2 (1880). Gastropoda and supplement to pt. 1, pp. 111 (73-183), pls. 10 (1 double), (vii-xvii).

" " " " 3 (1881). Pelecypoda, pp. 144 (185-328), pls. 8 (xvii-xxiv).

" " " " 4 (1882-85). Brachiopoda, pp. 442 (329-770), pls. 62 (xxv-lxxxvi).

" " " " 5 (1885). Bryozoa-Annelida-Echinodermata, pp. 64 (771-834), pls. 10 (lxxxvii-xcvi).

" " " " 6 (1886). Coelenterata, pp. 90 (835-924), pls. 20 (xcvii-cxvi).

" " " " 7 (1887). Coelenterata, Protozoa, pp. 74 (925-998), pls. 12 (cxvii-cxxviii).

Fossils from the Ceratite Formation: Vol. II, pt. 1 (1895). Pisces-Ammonoidea, pp. 324, pls. 40.

Geological Results: Vol. IV, pt. 1 (1889), pp. 1-88, pls. 4 (*out of print*).

" " " " 2 (1891), pp. 89-242, pls. 8 (*out of print*).

(SER. XV.)—HIMALAYAN FOSSILS.

Upper-triassic and liassic fauna of the exotic blocks of Malla Johar in the Bhot Mahals of Kumaon: Vol. I, pt. 1 (1903), by Dr. C. Diener, pp. 100, pls. 16 (1 double).

Anthracolithic Fossils of Kashmir and Spiti: Vol. I, pt. 2 (1899), by Dr. C. Diener, pp. 96, pls. 8.

The Permocarboniferous Fauna of Chitichun No. I: Vol. I, pt. 3 (1897), by Dr. C. Diener, pp. 105, pls. 13.

The Permian Fossils of the Productus Shales of Kumaon and Garhwal: Vol. I, pt. 4 (1897), by Dr. C. Diener, pp. 54, pls. 5.

The Permian Fossils of the Central Himalayas: Vol. I, pt. 5 (1903), by Dr. C. Diener, pp. 204, pls. 10.

The Cephalopoda of the Lower Trias: Vol. II, pt. 1 (1897), by Dr. C. Diener, pp. 182, pls. 23.

The Cephalopoda of the Muschelkalk: Vol. II, pt. 2 (1895), by Dr. C. Diener, pp. 118, pls. 31.

- Upper Triassic Cephalopoda Fauna of the Himalaya : Vol. III, pt. 1 (1899), by Dr. E. von Mojsalsky, pp. 157, pls. 22.
 Trias Brachiopoda and Lamellibranchiata : Vol. III, pt. 2 (1899), by Alexander Bittner, pp. 76, pls. 12 (2 double).
 The Fauna of the Spiti Shales : Vol. IV, Pt. 1, Fasc. 1 (1903), pp. 132, pls. 18; Fasc. 2 (1910), pp. 133-306, pls. 47 (2 double). By Dr. V. Uhlig.
 The Fauna of the Tropites-Limestone of Byans : Vol. V, Memoir No. 1 (1906), by Dr. C. Diener, pp. 201, pls. 17 (1 double).
 The Fauna of the Himalayan Muschelkalk : Vol. V, Memoir No. 2 (1907), by Dr. C. Diener, pp. 140, pls. 17 (2 double).
 Ladinio, Carnic and Noric faune of Spiti : Vol. V, Memoir No. 3 (1908), by Dr. C. Diener, pp. 157, pls. 24 (6 double).
 Lower-Triassic Cephalopoda from Spiti, Malla Johar and Byans : Vol. VI, Memoir No. 1 (1908), by Drs. A. von Kraft and C. Diener, pp. 186, pls. 31.
 The Fauna of the Traumatocrinus Limestone of Painkhanda : Vol. VI, Memoir No. 2 (1908), by Dr. C. Diener, pp. 39, pls. 5.
 The Cambrian Fossil of Spiti : Vol. VII, Memoir No. 1 (1910), pp. 70, pls. 6, by F. R. C. Reed.
 The Ordovician and Silurian fossils from the Central Himalaya : Vol. VII, Memoir No. 2 (*in the Press*), by F. R. C. Reed.

(SER. XVI).—BALUCHISTAN FOSSILS, by FRITZ NOETTLING, Ph.D., F.G.S.

- The Fauna of the Kellaways of Mazār Drik : Vol. I, pt. 1 (1895), pp. 22, pls. 13.
 The Fauna of the (Neocomian) Belemnite Beds : Vol. I, pt. 2 (1897), pp. 6, pls. 2.
 The Fauna of the Upper Cretaceous Maestrichtien Beds of the Mari Hills : Vol. I, pt. 3 (1897), pp. 79, pls. 23.

(NEW SERIES.)

- The Cambrian Fauna of the Eastern Salt-range : Vol. I, Memoir 1 (1899), K. Redlich, pp. 14, pl. 1.
 Notes on the Morphology of the Pelecypoda : Vol. I, Memoir 2 (1899), Fritz Noetting, pp. 58, pls. 4.
 Fauna of the Miocene Beds of Burma : Vol. I, Memoir 3 (1901), Fritz Noetting, pp. 378, pls. 25 (*out of print*).
 Observations sur quelques Plantes Fossiles des Lower Gondwanas : Vol. II, Memoir 1 (1902), R. Zeiller, pp. 39, pls. 7.
 Perno-Carboniferous (Lower Gondwana) Plants and Vertebrates from Kashmir : (1) Plants, by A. C. Seward; (2) Fishes and Labyrinthodonts, by A. Smith Woodward : Vol. II, Memoir No. 2 (1905), pp. 13, pls. 3.
 The Lower Palaeozoic Fossils of the Northern Shan States, Upper Burma : Vol. II, Memoir No. 3 (1906), by F. R. C. Reed, pp. 154, pls. 8.
 The Fauna of the Napeng Beds or the Rhatic Beds of Upper Burma : Vol. II, Memoir No. 4 (1908), by Miss M. Healey, pp. 88, pls. 9.
 The Devonian Faunas of the Northern Shan States : Vol. II, Memoir No. 5 (1908), by F. R. C. Reed, pp. 183, pls. 20.
 The Mollusca of the Ranikot Series : Vol. III, Pt. 1, Memoir No. 1 (1909), by M. Cossmann and G. Pisarro Introduction, by E. W. Vredenburg.
 On some Fish-remains from the Beds at Dongargaon, Central Provinces : Vol. III, Memoir No. 3 (1908), by A. Smith Woodward, pp. 6, pl. 1.
 The Fossil Giraffidae of India : Vol. III, Memoir No. 4 (*in the Press*), by G. E. Pilgrim.

•

The price fixed for these publications is four annas (4 pence) per single plate, with a minimum charge of Re. 1.

RECORDS OF THE GEOLOGICAL SURVEY OF INDIA.

VOL. I, 1868.

- Part 1 (out of print).*—Annual report for 1867. Coal-seams of Tawa valley. Coal in Garrow Hills. Copper in Bundalkund. Meteorites.
- Part 2 (out of print).*—Coal-seams of neighbourhood of Chanda. Coal near Nagpur. Geological notes on Surat collectorate. Cephalopodous fauna of South Indian cretaceous deposits. Lead in Raipur district. Coal in Eastern Hemisphere. Meteorites.
- Part 3 (out of print).*—Gastropodous fauna of South Indian cretaceous deposits. Notes on route from Poona to Nagpur *via* Ahmednuggur, Jalna, Loonar, Yeotmal, Mangali and Hingunghat. Agate-flakes in phocene (?) deposits of Upper Godavary. Boundary of Vindhyan series in Rajputana. Meteorites.

VOL. II, 1869.

- Part 1 (out of print).*—Valley of Poorna river, West Berar. Kuddapah and Kurnool formations. Geological sketch of Shillong plateau. Gold in Singhboom, etc. Wells at Hazareebagh. Meteorites.
- Part 2.*—Annual report for 1868. Pangshura tecta and other species of *Ohelonia* from newer tertiary deposits of Nerbudda valley. Metamorphic rocks of Bengal.
- Part 3.*—Geology of Kutch, Western India. Geology and physical geography of Nicobar Islands.
- Part 4 (out of print).*—Beds containing silicified wood in Eastern Prose, British Burma. Mineralogical statistics of Kumaon division. Coal-field near Chanda. Lead in Raipur district. Meteorites.

VOL. III, 1870.

- Part 1.*—Annual report for 1869. Geology of neighbourhood of Madras. Alluvial deposits of Irrawadi, contrasted with those of Ganges.
- Part 2 (out of print).*—Geology of Gwalior and vicinity. Slates at Chitali, Kumaon. Lead vein near Chicholi, Raipur district. Wardha river coal-fields, Berar and Central Provinces. Coal at Karba in Bilaspur district.
- Part 3 (out of print).*—Mohpani coal-field. Lead-ore at Slimanabad, Jabalpur district. Coal east of Chhattisgarh between Bilaspur and Ranchi. Petroleum in Burma. Petroleum locality of Sudkal, near Kuttijung, west of Rawalpindi. Argentiferous galena and copper in Manbhumi. Assays of iron ores.
- Part 4 (out of print).*—Geology of Mount Tilla, Punjab. Copper deposits of Dalbhum and Singhbhum : 1.—Copper mines of Singhbhum : 2.—Copper of Dalbhum and Singhbhum. Meteorites.

VOL. IV, 1871.

- Part 1.*—Annual report for 1870. Alleged discovery of coal near Gooty, and of indications of coal in Cuddapah district. Mineral statistics of Kumaon division.
- Part 2.*—Axial group in Western Prose. Geological structure of Fothern Konkan. Supposed occurrence of native antimony in the Straits Settlements. Deposit in boilers of steam-engines at Raniganj. Plant-bearing sandstones of Godavari valley, on southern extensions of Kamthi group to neighbourhood of Ellore and Rajamandri, and on possible occurrence of coal in same direction.
- Part 3.*—Borings for coal in Godavari valley near Dumagudem and Bhadrachalam. Narbada coal-basin. Geology of Central Provinces. Plant-bearing sandstones of Godavari valley.
- Part 4.*—Ammonite fauna of Kutch. Naigur and Hengir (Gangpur) Coal-field. Sandstones in neighbourhood of first barrier on Godavari, and in country between Godavari and Ellore.

VOL. V, 1872.

- Part 1.*—Annual report for 1871. Relations of rocks near Murree (Mari), Punjab. Mineralogical notes on gneiss of South Mirzapur and adjoining country. Sandstones in neighbourhood of first barrier on Godavari, and in country between Godavari and Ellore.
- Part 2.*—Coasts of Baluchistan and Persia from Karachi to head of Persian Gulf, and some of Gulf Islands. Parts of Kummummet and Hanamonda districts in Nizam's Dominions. Geology of Orissa. New coal-field in south-eastern Hyderabad (Deccan) territory.

- Part 3.*—Maskat and Massandim on east coast of Arabia. Example of local jointing. Aerial group of Western Proms. Geology of Bombay Presidency.
- Part 4.*—Coal in northern region of Satpura basin. Evidence afforded by raised oyster banks on coasts of India, in estimating amount of elevation indicated thereby. Possible field of coal-measures in Godavari district, Madras Presidency. Lameta or intratrappean formation of Central India. Petroleum localities in Pegu. Supposed eoconal limestone of Yellam Bile.

—VOL. VI, 1873.

- Part 1.*—Annual report for 1872. Geology of North-West Provinces.
- Part 2.*—Bisrampur coal-field. Mineralogical notes on gneiss of south Mirzapur and adjoining country.
- Part 3.*—Celt in ossiferous deposits of Narbada valley (Pliocene of Falconer): on age of deposits, and on associated shells. Barakara (coal-measures) in Beddadanoile field, Godavari district. Geology of parts of Upper Punjab. Coal in India. Salt-springs of Pegu.
- Part 4.*—Iron deposits of Chanda (Central Provinces). Barren Islands and Narkondam. Metalliferous resources of British Burma.

VOL. VII, 1874.

- Part 1 (out of print).*—Annual report for 1873. Hill ranges between Indus valley in Ladak and Shah-i-Dula on frontier of Yarkand territory. Iron ores of Kumaon. Raw materials for iron-smelting in Raniganj field. Elastic sandstone, or so-called Itacolunyte. Geological notes on part of Northern Hazaribagh.
- Part 2 (out of print).*—Geological notes on route traversed by Yarkand Embassy from Shah-i-Dula to Yarkand and Kashgar. Jade in Karakas valley, Turkistan. Notes from Eastern Himalaya. Petroleum in Assam. Coal in Garo Hills. Copper in Narbada valley. Potash-salt from East India. Geology of neighbourhood of Mari hill station in Punjab.
- Part 3.*—Geological observations made on a visit to Chaderkul, Thian Shan range. Former extension of glaciers within Kangra district. Building and ornamental stones of India. Materials for iron manufacture in Raniganj coal-field. Manganese-ore in Wardha coal-field.
- Part 4 (out of print).*—Auriferous rocks of Dhambal hills, Dharwar district. Antiquity of human race in India. Coal recently discovered in the country of Luni Pathans, south-east corner of Afghanistan. Progress of geological investigation in Godavari district, Madras Presidency. Subsidiary materials for artificial fuel.

VOL. VIII, 1875.

- Part 1.*—Annual report for 1874. The Altum-Artush considered from geological point of view. Evidences of 'ground-ice' in tropical India, during Talcir period. Trials of Raniganj fire-bricks.
- Part 2 (out of print).*—Gold-fields of south-east Wynad, Madras Presidency. Geological notes on Khareean hills in Upper Punjab. Water-bearing strata of Surat district. Geology of Scindia's territories.
- Part 3 (out of print).*—Shahpur coal-field, with notice of coal explorations in Narbada region. Coal recently found near Mofiong, Khasia Hills.
- Part 4 (out of print).*—Geology of Nepal. Raigarh and Hingir coal-fields.

VOL. IX, 1876.

- Part 1 (out of print).*—Annual report for 1875. Geology of Sind.
- Part 2.*—Retirement of Dr. Oldham. Age of some fossil floras in India. Cranium of *Stegodon Ganessa*, with notes on sub-genus and allied forms. Sub-Himalayan series in Jammu (Jammoo) Hills.
- Part 3.*—Fossil floras in India. Geological age of certain groups comprised in Gondwana series of India, and on evidence they afford of distinct zoological and botanical terrestrial regions in ancient epochs. Relations of fossiliferous strata at Maleri and Kota, near Sironcha, C. P. Fossil mammalian faunas of India and Burma.
- Part 4.*—Fossil floras in India. Osteology of *Merycopotamus dissimilis*. Addenda and Corrigenda to paper on tertiary mammalia. Plesiosaurus in India. Geology of Pir Panjal and neighbouring districts.

VOL. X, 1877.

- Part 1.*—Annual report for 1876. Geological notes on Great Indian Desert between Sind and Rajputana. Cretaceous genus *Omphalia* near Nameho lake, Tibet, about 75 miles north of Lhasa. *Esteria* in Gondwana formation. Vertebrata from Indian tertiary and secondary rocks. New Emydine from the upper tertiaries of Northern Punjab. Observations on under-ground temperature.

RECORDS OF THE GEOLOGICAL SURVEY OF INDIA.

Part 4.]

1910.

[May.

**GEOLOGY AND PROSPECTS OF OIL IN WESTERN PROME
AND KAMA, LOWER BURMA (INCLUDING NAMAYAN,
PADAUNG, TAUNGBOGYI, AND ZIAING). BY MURRAY
STUART, B.SC., F.G.S., *Assistant Superintendent,
Geological Survey of India.* (With Plate 23.)**

THE localities described below include Namayan, Padaung, Ziaing, and Taungbogyi in western Prome, and Kama in western Thayetmyo (see Pl. 23). At each of

List of localities described below.

these, oil seepage occurs or has occurred in recent years. All of these localities were mapped by W. Theobald in the years 1861—1873, but the scale of his map (8 inches=1 mile) was too small to permit of anything but the largest divisions being made.

The rocks occurring in the area mapped belong to the following series, described by Theobald in the *Memoirs, Geological Survey of India*, Vol. X¹ :—

Rocks occurring in the district.

Newer Alluvium.	}	Recent.
Older Alluvium.		

Irrawaddy series (" Fossil-wood group ").

Pegu system.

Nummulitic series.

So far as the older¹ and newer alluvium beds are concerned, I have merely mapped them where they occur to any extent, without any further examination, and have confined my detailed examination to the rocks of the Pegu system, especially with regard to its relations to the underlying Nummulitic series on the one hand and the overlying Irrawaddy² series on the other. I may mention here, however, that around Thingan there is a deposit of kankar, somewhat argillaceous and covering an area of some square miles, which corresponds to the Older Alluvium in other parts of the district. It has a gentle dip to the south and completely masks the underlying rocks. Where it is traversed by streams, the calcareous matter has been dissolved and redeposited in thick masses of non-argillaceous kankar. It is interesting in that it contradicts the view put forward by Theobald that such kankar deposits do not occur in Pegu (*Memoirs, Geological Survey of India*, Vol. X, part 3, page 46), and its occurrence brings the Older Alluvium of Pegu into closer similarity with that of India.

At the same time I have mapped the rocks of the Pegu system itself in some detail, and have everywhere succeeded with little difficulty in distinguishing the subdivisions suggested by Theobald, viz. :—

Divisions of the Pegu series.

4. Kama clays.
3. Upper Prome series (section B of Theobald).³
2. Lower Prome series (section A of Theobald).
1. Sitsayan shales.

I can add little or nothing to Theobald's detailed and admirable description of these rocks, except to confirm the suggestion of Noetling, that the rocks described in section B (Upper Prome series) do not comprise the whole of that division, but that there is a considerable thickness of these

Theobald's section of the Upper Prome beds incomplete.

¹ This older alluvium is the equivalent of the Red Alluvium Silt or Red Alluvium frequently referred to by other writers subsequent to Theobald.

² This is identical with the Fossil-wood group mentioned by Theobald.

³ *Memoirs, Geol. Surv. Ind.*, Vol. X, pt. 3, p. 84.

beds hidden by the channel of the Irrawaddy at the point where Theobald's observations were taken.¹

It is my intention to adhere throughout the paper to Theobald's

Theobald's scheme of classification adopted in preference to Dr. Noetling's.

scheme of classification, as given above, in preference to Noetling's later scheme of classification which consisted of the 'Yenangyaungian' and 'Promeian,' and

wherever in the subsequent pages I refer to Prome beds I mean the Prome beds of Theobald's classification and not the Promeian of Noetling. My reasons for preferring Theobald's scheme to that of Noetling I give on a later page in this paper.

The thickness of the Upper Prome beds where they occur by Thebyu,

Real thickness of the Upper Prome series.

just to the north of Prome, where their full thickness is exposed, is in the neighbourhood of 2,200 feet.

Leaving for the time the question of what beds occur over the Prome

Stratigraphical position of the Kama clays.

beds at this particular point, Theobald was perfectly correct in assuming that the Kama clays follow directly upon the Upper

Prome series in the general section of the Pegu rocks.

The rocks of the district shown on the map speaking generally dip

General structure of the district.

in a direction ranging from north-east to east, and have developed a subsidiary synclinal fold between Padaung and Ziaing.

The main feature of the country is a large fault which runs in a N.N.W. direction, and passes through the mud volcanoes and salt springs indicated by Theobald.² Its effect is considerable, for at Thingan, Sitsayan shales on the east of the fault are faulted against Kama clays on the west, and similarly at Sinda the lowest beds of the Lower Prome series are faulted against beds high in the Kama clays. It is most probable that it is not a simple fault, but that it is combined with a horizontal movement of the beds west of it in a N.N.W. direction.

West of this fault and north of Padaung there is a syncline and

Detailed structure west of the fault.

anticline of Pegu rocks: Kama clays occurring in the trough of the syncline and on the eastern flank of the anticline, while

lower Prome beds are exposed along the crest of the anticline. To the

¹ *Pal. Ind.*, New Series, Vol. I, pt. 3, p. 22.

² "Salt Springs of Pegu." *Records, Geol. Surv. Ind.*, Vol. VI, p. 67.

north these folds are cut off by the fault, but to the south they end abruptly near Kayinzu, where the lowest beds of the Kama clays outcrop in the Irrawaddy dipping E.S.E. It is from these beds of the Kama clays that the oil seepage at Kayinzu used to occur, but the seepage is reported to have been exceedingly slight and has not been observed for several years.

In the Prome beds opposite Prome and east of the fault this synclinal and anticlinal structure again occurs, but to a very much smaller extent, being confined to the Upper and Lower Prome series and only extending from Ziaing on the north to Kyaukthinmaw to the south. North and south of these places the rocks dip in a general easterly direction.

On tracing the base of the Sitsayan shales over the sandstones and clays of the Nummulitic series, it became at once evident that they do not form a conformable sequence as hitherto supposed, but that a considerable unconformity occurs between the two groups; for, though the difference in direction and amount of dip was not apparent in any individual section, yet as I traced the junction from north to south I found that the Sitsayan shales overlap bed after bed of the Nummulitic series. Also the Sitsayan shales contain near their base occasional worn fragments of the Nummulitic sandstones and limestones.

The general strike of the beds of the Nummulitic series is north-west, while the base of the Sitsayan shales traces an irregular line which has roughly a north and south direction. I made no attempt to measure the thickness of the Sitsayan shales, because no section occurred where such a proceeding was possible.

Overlying the Sitsayan shales comes the Lower Prome series (section A of Theobald), by no means unfossiliferous as Noctling has assumed,¹ but containing no distinctive fossil horizons. Thus, from the massive sandstones at the base of the series, where they outcrop by Sinda village, I obtained abundant echinoderms and sharks' teeth.² The echinoderms being

¹ *Pal. Ind.*, New Series, Vol. I, pt. 3, p. 7.

² *Infra*, p. 292

in each case surrounded by ferruginous concretion, it was impossible to determine the species to which they belong. From the same bed I obtained the cephalothorax of a brachyurous crab measuring five inches in width, but the specimen does not admit of determination.

About fifty feet below the top of this series of beds, that is to say, fifty feet below the bed containing *Cytherea*

Fossils from the Lower Prome series.

erycina which outcrops opposite Prome, there occurs a bed filled with *Turritella simplex*, Jenkins, and *Turritella acuticarinata*, Dunker. Therefore it is evident that these two *Turritellae* can no longer be considered as forming one of the highest zones in the Pegu beds,¹ as suggested by Noetling. Between this and the fish teeth zone I found an imperfect shell belonging to the *Conus* family. Where the Lower Prome series is exposed near Kama it is much more fossiliferous than is the case opposite Prome, the most frequent fossils being :—

Flabellum distinctum, Milne Edwards.

Dione sp.

Turritella sp.

Vermetus javanus, K. Martin.

Ficula sp., Noetling.²

Conus sp.

This is not intended to represent an exhaustive list of the fossils in the Lower Prome series, but is rather given to show that these beds are by no means unfossiliferous as assumed by Noetling. Nevertheless as a rule this series contains few fossils throughout the district mapped.

Following these beds in normal sequence comes the Upper Prome series, of which the lowest 541 feet are described by

The occurrence of *Cytherea erycina* in the Upper Prome series.

Theobald in his section B.³ These beds have for their base opposite Prome a bed containing abundant *Cytherea erycina*, Fav., and where their full development is seen near Thebyu are about 2,200 feet in thickness. At Kama a similar thickness of them is exposed, consisting of sandstones and shaly beds, crowded with fossils and containing *Cytherea erycina* in the greatest profusion from bottom to top. This of course destroys all value of *Cytherea erycina* as a zone

¹ See *Pal. Ind.*, New Series, Vol. I, pt. 3, p. 26.

² *Pal. Ind.*, New Series, Vol. I, pt. 3, p. 299.

³ *Memoirs, Geol. Surv. Ind.*, Vol. X, pt. 3, p. 84.

fossil ; but it should be remembered, however, that the zone fossils constituting the basis of Noetling's nomenclature do not characterise exclusively the horizons named after them. In most cases the mollusca of the Pegu system range through a number of successive horizons, and Noetling's zones are named after certain forms which happened to be particularly abundant in certain beds of the sections he studied. The faunistic constitution of the zones is, however, to a great extent a matter of facies, and the reappearance of any particular form in another section at a distance from Noetling's type sections by no means signifies that they are on the same horizon. This applies particularly to forms such as *Cytherca erycina*, Fav., which are regarded as identical with shells that are still living. If the zone names used by Noetling are retained, it should be kept in mind that they must be taken to indicate the same horizons as in the original scheme, irrespective of the exact faunistic constitution at any particular locality.

The general character of the Upper Prome series, which consists of alternations of massive and shaly sandstones and shales, is softer than that of the Lower Prome series ; the outcrops are characterised by lower hills than those formed by the beds of the Lower Prome series. In fact the two divisions can generally be distinguished throughout the district by the difference in the physical features of their outcrops. The uppermost beds of this series form the zone of *Parallelipedium prototortuosum* described by Noetling. This year, Mr. H. J. Davies, Geologist to the Burma Oil Company, has discovered at the top of this series a bed crowded with *Ostrea*, which were immediately recognized by Mr. E. Vredenburg as being *Ostrea latimarginata*, Vred., thus giving a parallel horizon with the Gaj in Sind, in Persia, in Cutch, and in Kathiawar.

I have this year found in these topmost beds of the Upper Prome series a species of *Turritella* which is different from any hitherto described from the Burmese tertiaries. It is characterised by three sharp revolving keels, of almost equal strength, which seem to persist up to the embryonic whorls. From the figures and description given by K. Martin in his "Die fossilien von Java" it seems to be comparable with *Turritella djadjariensis*, Mart. It has also been found by Mr. Davies in his zone of *Ostrea latimarginata*, Vred., and seems to occur in the topmost beds of the Upper Prome series and possibly the basal beds of the Kama clays.

Above these beds follows a series of shales with sandy beds and occasional sandstones, which are the Kama clays mentioned by Theobald. These beds are crowded with fossils, of which perhaps the most important is *Arca theobaldi*, Noetling, which occurs near the base and forms the zone of that name described by Noetling.

This top division is the most important of all the divisions of the Pegu beds from an economic point of view, because it is from it that all the oil seepages reported in the district occur, thus contradicting Noetling's theory that the oil-bearing strata were all in his Promeian division, *i.e.*, the Lower Prome series and the Sitsayan shales. The exudation of gas at Kama comes from these Kama clays; the oil seepage near Thingan comes from them close to where they are cut off by the fault; the seepage at Kayinzu comes from the very base of these beds, while the seepage at Namayan cannot come from beds older than these clays.

The fossils occurring in these clays at Kama have already been described by Noetling in his memoir.¹ Where they out-crop near Thingan, I obtained the following:—

Dendrophyllium sp.,
Dione sp.,
Turritella acuticarinata, Dunker,
Vermetus javanus, K. Martin,
Marginella (Glabella) scripta, Reeve,
Genota irravadica, Noetling;

while from a similar horizon near Thebyu I obtained :—

Arca sp.,
Leda virgo, K. Martin,
Dione sp.,
Corbula socialis, K. Martin,
Marginella (Glabella) scripta, Reeve,
Pleurotoma karenica, Noetling,
Conus awaensis, Noetling.

¹ Zone of *Arca theobaldi*.

Having described these beds, it remains now to deal with the beds that overlie the Kama clays. While mapping in the neighbourhood of Padaung, I was much puzzled by some beds which formed a marked ridge at Tamagon, and there seemed to lie conformably upon the Upper Prome series, but which when traced northwards swing unconformably across the Kama clays and are cut off by the fault. They consist of coarse yellow grits and occasional conglomerates, more or less ferruginous, and yellow sands. They contain marine fossils, most of which occur in the Pegu rocks, but are characterised by the abundance of *Ostrea* among the forms.

Marine beds which overlie the Kama clays, west of the Irrawaddy. A small patch of these rocks is exposed in the trough of the syncline near Myaungshe, and also on the eastern shore of the Irrawaddy at Namayan. It was not, however, until I worked north of Prome that the age of these rocks became clear.

In the stream near Thebyu the topmost beds of the Lower Prome series are exposed. Overlying these follows the whole series of the Upper Prome beds, and over these again lie the Kama clays, of which about 1,200 feet are seen. Over these Kama clays is a series of grits and sandstones, containing marine fossils: these beds are the exact counterpart of the Tamagon beds. They pass upwards into yellow sandstones with few fossils and these in turn are covered up and concealed by a thick deposit of the gravels of the older alluvium.

Unconformity between Kama clays and overlying marine grits. As the junction of the grits and the Kama clays is traced southwards, it becomes apparent that these grits are lying unconformably across the clays, and are creeping more and more across their outcrop towards the top of the Upper Prome series. The actual spot where these grits do actually overlap and conceal the Kama clays is not visible, but is somewhere in the channel of the Irrawaddy opposite Prome.

The beds at Prome described by Theobald as the upper members of the Pegu group, and as passing conformably upwards into the Irrawaddy series, are these grits and sandstones which are lying unconformably upon Kama clays and Upper Prome beds.

Marine beds above unconformity pass conformably into beds of Irrawaddy series.

South of Prome these basal grits are seen in the Mauchaung stream to be lying directly upon the Upper Prome series.

In view of this unconformity and the absolute difference of their lithological character from that displayed by the rocks of the Pegu series it is impossible to class them with that system, but they must of necessity be classed with the beds of the Irrawaddy series, with which they are apparently quite conformable, and with which they agree much more closely in lithological character.

In the *Records of the Geological Survey of India*, Vol. 2, part 4, Theobald divides his Fossil-wood group (since called Irrawaddy series) into three divisions, naming the lowest division the Mogoung sands which he describes as follows :

“ Mogoung sands.

A mixed assemblage of shales, sands and conglomerates, the last very subordinate, Towards the base the beds contain marine shells and pass into those of the next group.”

These marine grits which I have described as lying unconformably upon the Kama clays and Upper Prome series undoubtedly correspond to the lowest and marine beds of Theobald's Mogoung sands. The beds themselves are of little importance, save that they show that it is unsafe to class a post-nummulitic rock containing marine fossils as belonging to the Pegu group without referring it to known beds of that group.

Another point which this unconformity emphasises is the impossibility of finding the horizon of any definite bed in the Pegu system by working down from the base of the overlying Irrawaddy series ; yet this seems to have been the procedure adopted by Noetling in fixing the position of the Lower Prome beds at Yenangyaung.¹

It will have been noticed that throughout this report I have carefully adhered to Theobald's divisions, merely calling his B and A sections of the Prome beds, Upper and Lower Prome series. I have carefully avoided using the divisions suggested by

Mogoung sands identical with marine beds at base of Irrawaddy series.

Impossibility of determining Pegu beds by working from Irrawaddy series.

Noetling's scheme of classification unsuitable.

¹ *Pal. Ind.*, New Series, Vol. I, pt. 3, p. 29.

Noetling, viz., Yenangyaungian (consisting of the Kama clays and Upper Prome series) and Promeian¹, (consisting of the Lower Prome series and Sitsayan shales), because I think they are totally unsuitable both as names and as divisions.

At Yenangyaung a series of Pegu shales and sands is exposed under the beds of the Irrawaddy series, and we have at present no evidence, structural or palæontological, that any part of these shales and sands may be on the same horizon or the equivalent of the hard massive sandstones of the Lower Prome series (the Upper division of Noetling's Promeian) exposed in Lower Burma. On the other hand I shall show in a subsequent paper¹ that it is most probable that all the Yenangyaung shales and sands overlies the Upper Prome series, that they are in fact the upper development of the Kama clays, which is obliterated in Lower Burma by the overlap of the Fossil-wood group. The difference of the Yenangyaung fauna from that existing in other places would fall in with this view. Be that as it may, I think it better at present to adhere to the terms Upper and Lower Prome series and to keep the Kama clays and Sitsayan shales distinct and separate, than to class the Lower Prome series and Sitsayan shales together as Upper and Lower Promeian, and the Kama clays and Upper Prome series as Upper and Lower Yenangyaungian. Such a division of the Pegu system has nothing to recommend it, whereas the Upper and Lower Prome series have similar lithological characters and fall naturally into one division, and the Sitsayan shales on the one hand and the Kama clays on the other have no characters in common with them, but must necessarily form divisions by themselves.

Summary.

The points adduced in the foregoing paper which are contrary to the views held hitherto are the following:—

1. Theobald's detailed description of the Upper Prome series does not comprise the whole of it, but only the base of the series.
2. The Pegu and Nummulitic systems do not form an unbroken sequence; on the contrary there is a distinct unconformity between the two.

¹ *Infra*, p. 290.

3. The Lower Prome series is by no means unfossiliferous as has been hitherto supposed.¹
4. The two forms, *Turritella simplex*, Jenkins, and *Turritella acuticarinata*, Dunker, can no longer be regarded as forming one of the highest zones in the Pegu system. They occur similarly in the Lower Prome series.
5. *Cytherea erycina*, Fav., occurs in the greatest profusion throughout the Upper Prome series.
6. The oil-bearing strata of the district are the Kama clays (the topmost division of Noetling's Yenangyaungian) and not either the Lower Prome series or the Sitsayan shales (which comprise Noetling's Promeian), hitherto supposed to be the oil-bearing strata.
7. The Kama clays are the topmost beds of the Pegu system in the district, which is contrary to what Theobald assumed.
8. There is a distinct unconformity between the Pegu and Irrawaddy systems.
9. The basal beds of the Irrawaddy system are marine throughout the district; which last two facts are contrary to the former idea that the two systems were perfectly conformable and that the Irrawaddy system did not contain any marine beds.
10. Noetling's scheme of classification of the Pegu system into Yenangyaungian and Promeian is not suitable for the subdivision of the system, which is more satisfactorily effected by Theobald's scheme.

Prospects of Oil.

Paduaung.—The oil seepage in this locality comes from the base of the Kama clays where they outcrop in the bed of the Irrawaddy, by Kayinzu. The only anticline in the neighbourhood runs N.N.W. from Kayinzu and has Lower Prome beds exposed along its crest. Since there is no evidence of oil in the Pegu series below the base of the Kama clays a boring in the anticline would probably not pass through any oil-bearing strata.

¹ Mr. L. Dalton claims to have found fossils in these rocks (*Quar. Journ. Geol. Soc.*, Vol. LXIV, p. 608), but it will be seen below (p. 274) that the horizon from which the fossils were obtained is really the equivalent of the Kama clays and not of the Lower Prome series.

Ziaing.—The remarks which I have made above apply in this case also. The oil seepage occurs from the Kama clays near Thingan and close to the fault. It occurs on about the same horizon as the seepage at Kayinzu. The only anticline in the vicinity is the one mentioned as stretching N.N.W. from Kayinzu, which is cut off by the fault near Thingan and contains no oil-bearing strata.

Namayan.—The horizon of the oil seepage here is a little more obscure, since the rocks are covered with alluvium to the west of the fault. The seepage occurs on the line of the fault and apparently comes from the beds on the west of it. These beds, from the general trend of the strata across the river, cannot be older than Kama clays. There is no anticlinal structure and it is useless to prospect for oil in the vicinity.

Taungbogyi.—The oil seepage used to occur here in some sandstones dipping steeply to the north-east. The beds belong to a series which contain Eocene *Orbitoides* and in its upper members Eocene nummulites. They are undoubtedly of Eocene age and are overlapped unconformably by the Sitsayan shales. There is no anticlinal structure in the vicinity. A boring was put down some years ago which failed to obtain oil at any depth, but encountered much water. Since that time all show or indication of oil has ceased. It is useless to prospect further here.

Kama.—Oil is reported here from a place south of the town where the base of the Kama clays outcrop, but as all the rocks are dipping steadily eastwards without any anticlinal structure oil cannot be expected in any quantity.

THE RECORRELATION OF THE PEGU SYSTEM IN BURMA
WITH NOTES ON THE HORIZON OF THE OIL-BEARING
STRATA (INCLUDING THE GEOLOGY OF PADAUKPIN,
BANBYIN AND AUKMANEIN). BY MURRAY STUART,
B.SC., F.G.S., *Assistant Superintendent, Geological
Survey of India.* (With Plate 24.)

THE localities described below are Padaukpin, Banbyin, and Aukmanein in western Thayetmyo, in each of which oil

Localities.

seepages occur. The country around Padaukpin and Banbyin has been repeatedly examined by the geologists and experts of the Burma Oil Company and a short chapter is devoted to it in a paper on the Geology of Burma recently read before the Geological Society by Mr. L. V. Dalton.¹ The country around Aukmanein (Pl. 24) has now been examined in detail for the first time.

The rocks outcropping near Aukmanein belong to the Lower and Upper Prome series (having the same

Rocks outcropping near Aukmanein, and unfavourable prospects for oil.

lithological characters as at Prome) and the Kama clays of the Pegu system.² Oil seepage occurs from the Kama clays near Aukmanein in the wet months, but since all the rocks are dipping eastwards at about 45°, the structure is very unfavourable for them to yield oil in quantity.

Above the Kama clays come the massive yellow and grey sandstones described by Theobald in the

Beds which overlie the Kama clays.

Memoirs of the Geological Survey of India, Vol. X, part 3, page 93. These sandstones, which seem to lie conformably upon the Kama clays when seen in any individual section, are found, on tracing their outcrop, to overlap the Kama clays unconformably and are obviously the equivalent of the basal marine beds of the Irrawaddy series already described by me in the preceding paper as existing around

¹ *Quar. Journ. Geol. Soc.*, Vol. LXIV, pt. 4.

² The term Prome series refers to Theobald's scheme of classification, not to Noetling's (see previous paper).

Prome.¹ As in the Prome district these beds contain marine fossils and pass conformably upwards into undoubted beds of the Irrawaddy series.

Theobald describes these beds as follows :—

“West and South-west of Thaitmio stretches a belt of low hills, much scored by ravines and made up of the fossil-wood beds already described. Theobald's description of the rock of the locality. The axis of this belt of country runs in a slightly curved line, with its concavity facing the river, from the village of Pima-khon, fourteen miles West-north-west from Thaitmio to Alayua, midway between Pulo and Kama, giving a length to this tract of twenty-five miles, by a breadth varying from six to ten miles. Leaving this belt of ground in a Westerly direction across the Pani (Punnee) stream, the character of the country gradually changes in accordance with the fact of our descending somewhat on to the lower beds, beneath the fossil-wood group. Across the Pani stream in place of the incoherent fossil-wood sands, we come on to not very dissimilar beds, but in which marine fossils are pretty common : and which, from the abundance in spots of that shell, may be termed *Turritella* sands ;” (It will be remembered that Theobald found these fossils in abundance in these beds at Prome.—M. S.) “and these beds are either very high in the series of the Prome group, or perhaps correspond in part with the Mogoung sands intervening between the Prome and fossil-wood groups.”

These marine beds pass upwards conformably into the typical beds of the Irrawaddy series and are then much covered and obscured by the gravels of the Older Alluvium. Up to the point where they pass under the Older Alluvium their dip is steadily east-north-east at about 30°, but when, near Nathe, they again outcrop they dip at about 10° in a west-south-west direction.

Here, in addition to marine fossils, they contain the fossil roots of a species of palm tree. One such fossil root which I examined had numerous sharks' teeth embedded in the coarse grits which existed between the rootlets. Obviously, therefore,

¹ *Supra*, p. 266.

the marine conditions were rapidly giving place to shallow water and estuarine conditions.

Eastwards from Nathe, successively lower and lower beds outcrop, until, near Padaukpin and Banbyin, the Kama clays of the underlying Pegu system appear, being exposed, generally, along the streams, where these have cut down through the gently dipping beds of the Irrawaddy series. It is in these clays that the oil occurs.

Further to the east the beds of the Irrawaddy series bend over and dip sharply east-north-east at about 65° , forming another syncline between here and the Myinbataung ridge to the east. The general structure, therefore, is that of a subsidiary anticline developed in the trough of a large syncline.

I do not think that the locality is likely to prove productive of oil because of the unconformity between the overlying Irrawaddy sandstones and the underlying Kama clays: for although there is a somewhat definite anticline in the Irrawaddy beds, yet there does not seem to be any very definite anticlinal structure in the underlying Kama clays, which show subordinate puckerings rather than any very definite anticline.

Fossils from the Kama clays at Padaukpin and Banbyin.

From the clays where they outcrop near Banbyin and Padaukpin I obtained the following fossils:--

Lithodomus sp.

Leda virgo, K. Martin.

Corbula socialis, K. Martin.

Turritella acuticarinata, Dunker.

Natica obscura, Sowerby.

Cerithium sp.

Ficula sp., Noetling.

Balanus tintinnabulum, Linné.

Hemipristis sericea, Agassiz.

The overlying marine beds of the Irrawaddy series contain many fossils, including frequent *Turritella acuticarinata*, as they do where they outcrop near Aukmanein.

Fossils in the marine beds of the Irrawaddy series.

In the paper on the Geology of Burma which I have previously mentioned as appearing in the *Quarterly Journal of the Geological Society*, Vol. LXIV, part 4, the author erroneously describes the bottom bed of this group,

The basal bed of the Irrawaddy series wrongly correlated.

where it overlies the Kama clays near Padaukpin, as the zone of *Cytherea erycina*, both because of the discovery in it of "a species of *Conus* and a poorly-preserved *Ceratotrochus* (possibly *C. alcockianus*)," and from the fact that oil occurred below this horizon, being misled in this instance by Noetling's view that oil always occurs below the zone of *Cytherea erycina* and not above it. It was from the Kama clays beneath these sandstones that he discovered a fossil which he regards as identical with the European form *Lucina globulosa*; but the value of the discovery was considerably diminished by the fact that the horizon in which it occurred was at that time not correctly determined. Where the Pegu series outcrops at the edge of the main syncline near Aukmanein, the Upper and Lower Prome series have practically the same lithological characters as at Prome, forming steep hills running to 1,400 feet in height; it is, therefore, unlikely that they have changed their character so completely in ten miles or so as to be here represented by shales.

The discovery of *Lucina globulosa* in the top of these shales, immediately underneath the unconformity, definitely fixes the horizon as of Helvetian-Tortonian age, since this fossil is characteristic of that horizon in Europe, while the base of the Kama clays is a known horizon because of the occurrence of the band of *Ostrea latimarginata*, which, as stated in the preceding paper, occurs at the top of the Upper Prome series.¹ The evidence given by the form *Lucina globulosa* is supported by the occurrence of the tooth *Hemipristis serra*, Ag., also, which is characteristic of Miocene and Pliocene age.² Both of these pieces of evidence are seen to be of the greatest importance, in the light of the discovery of *Ostrea latimarginata* by Mr. H. J. Davies.

¹ Page 264.

² See the next paper, p. 293,

I am indebted to Mr. E. Vredenburg for the following information as to the horizon of *Ostrea latimarginata* :—

“ This *Ostrea latimarginata* is the most characteristic fossil of the uppermost zone of the Gaj in Sind, in Persia, in Cutch, and in Kathiawar. The Gaj in Sind contains large lepidocyclines of the group *L. marg'nata* and cannot be newer than Upper Aquitanian. It is just possible that the uppermost zone with *Ostrea latimarginata* may be Burdigalian.”¹

Consequently, the thickness of the Kama clays existing at Padaukpin and Banbyin represents the whole of the Burdigalian and at least the lower portion of the Middle Miocene as represented by Helvetian-Tortonian beds. Even without the fossils it is at once evident that a large thickness of beds of age newer than the basement beds of the Kama clays must exist here as a result of the unconformity.

At Aukmanein (see section, plate 24) the beds of the Irrawaddy series are dipping at about 30°, while the underlying Pegu group is dipping from 40° to 45° eastwards. This difference of dip is practically the same

Structural evidence indicates the same deductions.

at Banbyin. Near Nathe the beds of the Irrawaddy series are dipping about 10° S.W., while the clays underneath are approximately horizontal, and further to the east where the beds dip eastwards the shales are dipping at angles from 70° to 80°, while the overlying sandstones are dipping from 60° to 70° (see section on plate 24). The underlying shales show subordinate puckerings, but, allowing fully for this, the thickness of the shales at Padaukpin and Banbyin must be very considerable compared with the thickness exposed at Aukmanein. The fauna, too, which is seen at Padaukpin and Banbyin is different in many respects from that seen in the Kama clays, which lie close above the Promé beds; but much stress cannot be laid upon this, because the occurrence of fossils at any place indicates that conditions were suitable for their deposition at that place, rather than indicating a definite horizon which may be recognized at some other point. *

¹ See note on occurrence of *Ostrea latimarginata* on pages 127—132 of this volume of the *Records*.

Since it is established that there is here a large thickness of Kama clays existing below the Irrawaddy series, I have little doubt that the different oilfields are a repetition of such structure, and the different fossils found in them are explained by the fact that different horizons of these shales are exposed in almost each oilfield; the thickness of shales existing in any individual field depends on the distance that oilfield is situated from the western boundary of the syncline where the Pegu beds outcrop, and also on the difference in the dip of the beds of the overlying Irrawaddy series and the shales throughout that distance.

Except in the oilfields we have no evidence that oil sands occur in the Pegu system below the base of the Kama clays. Even in the oilfields the only evidence we have is that given by Noetling's identification of beds of the age of the Lower Prome series (which form the upper division of this Promeian). This identification is not supported by any structural evidence. Indeed, in view of the big unconformity which I have shown to exist between the Irrawaddy and Pegu systems, and the structure of the Padaukpin area especially, the structural evidence contradicts rather than supports such a correlation. It is even more strongly contradicted by the fossil evidence. The fauna of the different oilfields is distinctly different from that of the Upper or Lower Prome series, and it will be shown on a later page that there is every reason to believe that the rocks exposed in the various oilfields are high in the Miocene system, whereas the base of the Kama clays as indicated by the discovery of *Ostrea latimarginata*, Vred., is lowermost miocene. That being so, it is safe to say that we have no definite evidence that oil sands occur in the Pegu system below the base of the Kama clays,¹ and consequently, as is the case in the Western Prome district, the idea put forward by Noetling that the oil must exist in the Lower Prome series and Sitsayan shales (Noetling's Promeian) is so far not justified. On the other hand the Kama clays (and here I mean the whole of the series of sands and clays intervening between the top of the Upper Prome series and the base of the Irrawaddy series) seem generally to contain oil throughout.

¹ Compare the evidence given in the preceding paper.

At Yenangyaung the development of the Kama clays seems to be even greater than at Padaukpin and Banbyin, and the existence of a terrestrial fauna (Noetling's zone of *Anoplotherium birmanicum*) seems to show that conditions were more nearly approaching the terrestrial conditions indicated by what are recognized there as the lowest beds of the Irrawaddy series: in other words, that the interval represented by the unconformity between the two systems is not so great there as it is at Padaukpin. The existence of the forms *Cyrena crawfurdi*, Noetling, and *Cyrena (Batissa) petrolei*, Noetling, both in the top beds of the Pegu shales and the basal conglomerate of the Irrawaddy series,¹ lends additional support to this view.

Dr. G. E. Pilgrim has kindly supplied me with the following information as to the horizon of the lowest beds of the Irrawaddy series at Yenangyaung:—

"I have examined the vertebrate fossils collected by Noetling in 1892 and by Grimes in 1897 from the lowest beds of the Irrawaddy series at Yenangyaung. They include—

Mastodon latidens, Clift.,
Aceratherium perimense, Lyd.,
Hippurion punjabiense, Lyd.,
Tetraconodon sp.,
Plumochœrus titan, Lyd.,
Hippopotamus irrawadicus, F. & C.,
Merycopotamus dissimilis, F. & C.,
Boselaphus sp.,
Cervus sp.

"This fauna is sufficient to fix the horizon of these beds definitely as Middle Siwalik, that is to say, as older than that of the fauna of the Siwalik hills and newer than that of the Lower Siwaliks of Sind and the Punjab. As nearly as possible this stage corresponds to the Pontian of Europe.

"Noetling also collected two teeth from the marine beds of the Pegu series at Yenangyaung which he figured in *Pal. Ind.*, New Series, Vol. I, plate XXV, figs. 24 and 25. under the name *Anoplotherium birmanicum*.

Noetling's determination
Anoplotherium bir-
manicum revised.

¹ *Memoirs, Geol. Surv. Ind.*, XXVII, pt. 2, pp. 58—60.

Apart from the poor preservation of the specimens, their particular character does not admit of any exact determination. I may, however, say that I am unable to refer either of them to *Anoplotherium*; one is an upper molar of a small sized and primitive member of the *Tragulidæ*, and the other is a lower molar of a selenodont suine animal allied to *Choeromeryx*. Another lower molar collected by Mr. Cunningham Craig from what would seem to be a similar horizon is allied to the last mentioned of Noetling's specimens although a different species. The specimens, while indicating that the beds in which they occur are newer than Aquitanian, admit of any age between that and Pontian."

In Lower Burma the basal beds of the Irrawaddy series are, as I have already explained, marine, and are separated by an unconformity from purely marine beds of the Pegu series.

That is to say, the conditions both before and after the unconformity were marine, passing upwards in later Irrawaddy times to estuarine and fresh-water conditions. The age of the unconformity has been fixed as post Helvetian-Tortonian by the previously mentioned discovery of *Lucina globulosa* below it, and it is probable that the unconformity is of Upper Tortonian age.

In Upper Burma and Yenangyaung the unconformity seems to be very small or absent, practically the whole series of beds being present; the first sign of the upheaval, marked by the unconformity in Lower Burma, is the occurrence of a fresh-water series of beds represented by Noetling's so-called zone of *Anoplotherium birmanicum*. This is followed by the marine beds mentioned by Mr. Pascoe (*Records, Geol. Surv. Ind.*, Vol. XXXVI, 1908, p. 135) which would correspond with the subsidence in Lower Burma which established the marine conditions prevailing there in earliest Irrawaddy times. These marine beds at Yenangyaung pass upwards into mixed beds containing few fossils except *Batissa*, and also much selenite and fossil-wood; these pass upwards into the fresh-water series, which has hitherto been classed as the Irrawaddy series at Yenangyaung, having the 'Red bed' for its base, and being Pontian and Younger in age.

It seems, therefore, that the so-called zone of *Anoplotherium birmanicum* is the equivalent of the unconformity in Lower Burma, and that the very slight unconformity between the 'Red bed' and those below it is

Classification of the beds which correspond to the unconformity of Lower Burma.

purely local in character, as has always been maintained by Mr. Pascoe. That is to say, the mixed series of beds down to the lowest fresh-water deposit, which have hitherto been classed as topmost Pegu, should be referred to the base of the Irrawaddy series; the Pontian age of the Red bed agrees certainly with the assignment of the so-called zone of *Anoplotherium birmanicum* (1,200 feet below the "Red bed") to the horizon of the unconformity in Lower Burma (of Upper Tortonian age). I believe Mr. Cunningham Craig, from the study of the volcanic rocks in Pakokku last year, came to the conclusion that the white bed (containing kaolin) which immediately underlies the Red bed at Yenangyaung could not possibly be the base of the Irrawaddy series, but must occupy a position some distance above the base. If this is so, it supports strongly the view deduced by me above from the study of the geology of Lower Burma. In any case it is impossible at present to correlate the marine basal beds of the Irrawaddy series in Lower Burma with the 'Red bed' in Upper Burma, and their true position cannot definitely be fixed without further examination. •

So far as is at present known, therefore, the correlation of the rocks discussed in this paper with the European scale is as follows:—

Age.	Europe.	Burma.
Upper Miocene . . .	Pontian . . .	Lowest beds of the Irrawaddy series with mammalian bones. (Marine beds uncertain.)
Middle Miocene . . .	Sarmatian . . .	Unconformity.
	Tortonian . . .	Kama clays (petroleum-bearing strata).
	Helvetian . . .	Ditto.
Lower Miocene . . .	Burdigalian . . .	Upper Prome series.
	Aquitania . . .	Lower Prome series.
Oligocene . . .	Stampian . . .	Sitsayan shales.
	Tongrian . . .	Unconformity.
Eocene . . .	....	Nummulites. (BASSEIN SYSTEM).

That is to say, the Kama clays, which seem to be the main oil-bearing strata, represent the Lower and at least part of the Middle Miocene of Europe, while the Prome series and Sitsayan shales, being earlier than lowermost Miocene and also post-Eocene, must be of Oligocene age.

Before closing this report I wish to review the fossil evidence at present known and to see how far it agrees with the evidence given in the previous pages that the shale series exposed in the different oilfields is really the upper development of the Kama clays seen in Prome.

The known zones of the Pegu system. So far as is definitely known there are three fossil zones of fixed horizon :—

The zone of *Arca theobaldi*, situated at the base of the Kama clays.

The zone of *Parallelipipedum prototortuosum*, situated at the top of the Upper Prome series.

The zone of *Cytherea erycina*, situated at the base of the Upper Prome series.

Between these lower two zones there are probably two more zones, *Aricia humerosa* and *Pholas orientalis*, but the exact position of these is not known.¹

On studying the distribution of the fossils found in the above zones in the various oilfields, it is at once noticeable that the greatest number of forms are common to the zone of *Arca theobaldi*, while few are known in the lowest zone of *Cytherea erycina*, which is at the very base of Noetling's "Yenangyaungian."

On the other hand there are a large number of forms present which are not known in any of the known zones enumerated above.

¹ *Pal. Ind.*, New Series, Vol. I, pt. 3, p. 31.

The following tables, compiled from Noetling's table showing the vertical distribution of the fossils, will make this evident¹ :—

Zone of Mytilus nicobaricus (Singu).

	Zone of <i>Cytherea erycina</i> (21 forms).	Zone of <i>Arca humerosa</i> (31 forms).	Zone of <i>Pholas orientalis</i> (28 forms).	Zone of <i>Paul. prototort.</i> (63 forms).	Zone of <i>Arca theobaldi</i> (58 forms).	Not known in the preceding zones.
<i>Paracynthius caeruleus</i> , Duncan	*	*	..
<i>Litua protosquamosa</i> , Noet.	*	..
<i>Pecten irradicus</i> , Noet.
<i>Vulsella lingua-tigris</i> , Noet.	*
<i>Mytilus nicobaricus</i> , Reeve
<i>Modiola buddhaica</i> , Noet.
„ <i>pseudobuddhaica</i> , Noet.
<i>Arca bistrigata</i> , Dunker
<i>Cardita saquesneli</i> , d'Archaie & Haine	..	*	..	*
„ <i>planicosta</i> , Noet.	*
„ cf. <i>mutabilis</i> , d'Arch. & Haine
<i>Crassatella dieneri</i> , Noet.
<i>Cardium minbuense</i> , Noet.	*	*
<i>Meiocardia metavulgaris</i> , Noet.
<i>Dione protolilacina</i> , Noet.	..	*	..	*	*	..
„ <i>amygdaloides</i> , Noet.	*	*	*	..
„ <i>protophilippinarum</i> , Noet.	..	*	*	*	*	..
<i>Tellina grimesi</i> , Noet.	..	*	*	*	*	..
<i>Gari deuterokingi</i> , Noet.
<i>Corbula rugosa</i> , Sowerby
<i>Dentalium junghuhni</i> , K. Martin	*
<i>Calliostoma blanfordi</i> , Noet.
<i>Basilissa loriotiani</i> , Noet.	*	..
<i>Solarium maximum</i> , Philippi	*	*	..
<i>Turritella simplex</i> , Jenkins	*	*	..
<i>Sillquaria</i> sp.

¹ *Pal. Ind.*, New Series, Vol. I, pt. 3, pp. 39-46.

Zone of Mytilus nicobaricus (Singu)—contd.

	Zone of <i>Cytherea erycina</i> (21 forms).	Zone of <i>Aricia humerosa</i> (31 forms).	Zone of <i>Pholas orientalis</i> (28 forms).	Zone of <i>Paral. prototort.</i> (63 forms).	Zone of <i>Arca theobaldi</i> (55 forms).	Not known in the preceding zones.
<i>Calyptraea rugosa</i> , Noet.
<i>Natica obscura</i> , Sowerby
• <i>Sigaretes neritoides</i> , Linné
<i>Cypraea grantii</i> , d'Arch. & Haimo
<i>Galeodea monilifera</i> , Noet.
<i>Ficula theobaldi</i> , Noet.
<i>Pyrula bucephala</i> , Lamarek.
„ <i>pseudobucephala</i> , Noet.
<i>Oliva rufula</i> , DuRoi
<i>Genota iravadica</i> , Noet.
<i>Clavatulæ fulminata</i> , Kiener, sp.
„ <i>profundifera</i> , Noet.
<i>Conus avensis</i> , Noet.
<i>Callianassa birmanica</i> , Noet.
<i>Lamna spallanzanii</i> , Bonaparte
<i>Carcharias gangeticus</i> , Müller & Henle
Number of forms common to each zone	6	10	8	16	14	22

Zone of Meiocardia metavulgaris (Singu).

	Zone of <i>Cytherea erycina</i> .	Zone of <i>Aricia humerosa</i> .	Zone of <i>Pholas orientalis</i> .	Zone of <i>Paral. prototort.</i>	Zone of <i>Arca theobaldi</i> .	Not known in the preceding zones.
<i>Paracynthia caeruleus</i> , Duncan
<i>Pecten iravadicus</i> , Noet.
<i>Avicula succinea</i> , Noet.
<i>Valisella lingua-tigris</i> Noet.

Zone of *Melocardia metavulgaris* (Singu)—*contd.*

	Zone of <i>Cytherea erycina</i> .	Zone of <i>Arca humerosa</i> .	Zone of <i>Pholas orientalis</i> .	Zone of <i>Paral. prototort.</i>	Zone of <i>Arca theobaldi</i> .	Not known in the preceding zones.
<i>Modiola buddhaica</i> , Noet.	*
<i>Lithodomus</i> sp.	*
<i>Arca bistrigata</i> , Dunker	*
<i>Nucula alcocki</i> , Noet.	*
<i>Leda birmanica</i> , Noet.	*
<i>Cardita scabrosa</i> , Noet.	*
„ <i>tjidamarensis</i> , K. Martin	*
„ <i>viquesneli</i> , d'Arch. & Haine	..	*	..	*	..	*
„ cf. <i>mutabilis</i> , d'Arch. & Haine	*
<i>Crassatella dieneri</i> , Noet.	*
<i>Melocardia metavulgaris</i> , Noet.	*
<i>Dione protolilacina</i> , Noet.	*	*
„ <i>pretophilippinarum</i> , Noet.	..	*	*	*	*	..
<i>Tellina grimesi</i> , Noet.	..	*	*	*	*	..
<i>Gari kingi</i> , Noet.	*
<i>Corbula rugosa</i> , Sowerby	*
<i>Calliostoma blanfordi</i> , Noet.	*
<i>Turcica protomonilifera</i> , Noet.
<i>Basilissa lorioliana</i> , Noet.	*	..
<i>Solarium maximum</i> , Philippi	*	*	..
<i>Cypraea granti</i> , d'Arch. & Haine	*
<i>Galeodea monilifera</i> , Noet.	*	..
<i>Ficula theobaldi</i> , Noet.	*	*
<i>Conus avaensis</i> , Noet.	..	*	*	*	*	..
<i>Balanus tintinnabulum</i> , Linné	..	*	..	*	*	..
<i>Callianassa birmanica</i> , Noet.	*	*	..
<i>Larrea spallanzanii</i> , Bonaparte	*
<i>Carcharias gangeticus</i> , Müller & Henle	*
Number of forms common to each zone	5	5	4	10	12	18

Zone of Dione dubiosa (Singu & Yenangyat).

	Zone of <i>Cytherea erycina</i> .	Zone of <i>Aricia humerosa</i> .	Zone of <i>Pholas orientalis</i> .	Zone of <i>Paral. prototort.</i>	Zone of <i>Arca theobaldi</i> .	Not known in the preceding zones.
<i>Lucina d'archiaciana</i> , Noet.	*
<i>Dione dubiosa</i> , Noet.	*
<i>Gorbula prototruncata</i> , Noet.	*	..
<i>Scalardia leptopleurata</i> , Noet.	*

Zone of Paracyathus caeruleus (Yenangyat).

	Zone of <i>Cytherea erycina</i> .	Zone of <i>Aricia humerosa</i> .	Zone of <i>Pholas orientalis</i> .	Zone of <i>Paral. prototortuosum</i> .	Zone of <i>Arca theobaldi</i> .	Not known in the preceding zones.
<i>Paracyathus caeruleus</i> , Duncan	*	*	..
<i>Eupsammia regalis</i> , Alcock	*
<i>Pecten irravadicus</i> , Noet.	*
<i>Arca bistrigata</i> , Dunker	*	*
<i>Nucula alcocki</i> , Noet.	*	..
<i>Lucina pagana</i> , Noet.	*
<i>Dione amygdaloides</i> , Noet.	..	*	*	*	*	..
„ <i>protophillippinarum</i> , Noet.	*	*	*	*	*	..
<i>Tellina hilli</i> , Noet.	..	*	*	*	*	..
<i>Gari kingi</i> , Noet.	*
<i>Solen</i> sp.	*
<i>Callostoma blanfordi</i> , Noet.	*
<i>Solarium maximum</i> , Philippi	*	*	..
<i>Torinia buddha</i> , Noet.
<i>Turritella affinisformis</i> , Noet.	*
<i>Siliquaria</i> , spec. 1, Noet.	*
<i>Calyptraea rugosa</i> , Noet.	..	*	*	..	*	..

Zone of Paracyathus caeruleus (Yenangyat)—contd.

	Zone of <i>Cytherea</i> <i>erycina</i> .	Zone of <i>Aricia</i> <i>numerosa</i> .	Zone of <i>Pholas</i> ori- entalis.	Zone of <i>Paral. pro-</i> <i>totofurvusum</i> .	Zone of <i>Arca theo-</i> <i>boldi</i> .	Not known in the preceding zones.
<i>Natica callosa</i> , Sowerby	*	*	..	*	*	..
„ <i>obscura</i> , Sowerby	*	*	..	*	*	..
<i>Sigaretus neritoideus</i> , Linné	*	*
<i>Cypraea granti</i> , d'Arch. & Haime
<i>Trivia smithi</i> , K. Martin	*
<i>Ficula theobaldi</i> , Noet.	*
<i>Triton pardalis</i> , Noet.	*	..
„ <i>neastriatulus</i> , Noet.	*	*	..
<i>Ranella prototubercularis</i> , Noet.	*	*	..
<i>Fusus seminudus</i> , Noet.	*
<i>Fasciolaria nodulosa</i> , Sowerby	*
<i>Murex</i> (?) <i>teihatchewi</i> , d'Arch. & H.	*
<i>Voluta dentata</i> , Sowerby.	*
<i>Oliva rufula</i> , Ducloux	*	..	*	*	..
<i>Cancellaria pseudocancellata</i> , Noet.	*
„ <i>davidsoni</i> , d'Arch. & Haime	*
„ <i>martiniana</i> , Noet.	*
<i>Terebrum</i> sp.	*
<i>Surecula feddeni</i> , Noet.	*	..
<i>Drillia yenangensis</i> , Noet.	*
<i>Conus malaccanus</i> , Hwass	*
„ <i>protofurvus</i> , Noet.	*
„ <i>galensis</i> , Noet.	*
<i>Balanus tintinnabulum</i> , Linné	*	*	..	*	*	..
<i>Callianassa birmanica</i> , Noet.	*	*	..
<i>Myliobates</i> sp.	*
<i>Lamna spallanzanii</i> , Bonaparte	*
<i>Carcharias gangeticus</i> , Müller & H.	*
<i>Otolithus</i> sp.	*
Number of forms common to each zone	5	8	6	14	16	26

Zone of Cancellaria martiniana (Minbu).

	Zone of <i>Cytherea</i> <i>erycina</i> .	Zone of <i>Arctia</i> hu- merosa.	Zone of <i>Pholas</i> orientalis.	Zone of <i>Paral. proto-</i> <i>tortuosum</i> .	Zone of <i>Arca theo-</i> <i>baldi</i> .	Not known in the preceding zones.
<i>Paracynthus caeruleus</i> , Duncan	*	*	..
<i>Pecten irradians</i> , Noet.	*
<i>Pinna</i> sp.	*
<i>Arca bistrigata</i> , Dunker	*
<i>Nucula alecocki</i> , Noet.	*	..
<i>Dione dubiosa</i> , Noet.	*
„ <i>protophilippinarum</i> , Noet.	*	*	*	*	*	..
<i>Tellina hilli</i> , Noet.	*	*	*
<i>Gari kingi</i> , Noet.	*
<i>Corbula prototruncata</i> , Noet.	*	..
<i>Calliostoma blanfordi</i> , Noet.	*
<i>Solarium maximum</i> , Philippi	*	*	..
<i>Torinia protodorsuosa</i> , Noet.	*	..
„ <i>buddha</i> , Noet.	*	*
<i>Discobolix minuta</i> , Noet.	*
<i>Scalaria spathlea</i> , Noet.	*
„ <i>birmanica</i> , Noet.	*
„ <i>irregularis</i> , Noet.	*
<i>Turritella affinis</i> , Noet.	*
<i>Calyptraea rugosa</i> , Noet.	*	..	*	..
<i>Natica callosa</i> , Sowerby	*	*	..	*	*	..
„ <i>obscura</i> , Sowerby	*	*	*	*	*	..
<i>Cypraea granti</i> , d'Arch. & Haine	*
<i>Cassis d'archaea</i> , Noet.	*
<i>Semicassis protojaponica</i> , Noet.	*
<i>Oniscidia minbuensis</i> , Noet.	*
<i>Ficula theobaldi</i> , Noet.	*
<i>Triton pardalis</i> , Noet.	*	..
<i>Ranella prototubercularis</i> , Noet.	*	*	..
<i>Fusus semilundus</i> , Noet.	*
<i>Fasciolaria nodulosa</i> , Sowerby	*
<i>Murex arrakanensis</i> , Noet.	*

Zone of *Cancellaria martiniana* (Minbu)—contd.

	Zone of <i>Cytherea erycina</i> .	Zone of <i>Arctia hucerosa</i> .	Zone of <i>Pholas orientalis</i> .	Zone of <i>Paral. prototectusum</i> .	Zone of <i>Arca theobaldi</i> .	Not known in the preceding zones.
<i>Volvaria birmanica</i> , Noet.
<i>Voluta ringens</i> , Noet.
„ <i>dentata</i> , Sowerby
<i>Oliva rufula</i> , Duclos
<i>Cancellaria davidsoni</i> , d'Arch. & Haime
„ <i>martiniana</i> , Noet
<i>Terebrum smithi</i> , K. Martin
<i>Subula</i> sp.
<i>Sarcula feddeni</i> , Noet.
<i>Genota irravadica</i> , Noet.
<i>Clavatula protonodifera</i> , Noet.
<i>Drillia protointerrupta</i> , Noet.
<i>Conus malaccanus</i> , Hwas
<i>Balanus tintinnabulum</i> , Linné
<i>Callianassa birmanica</i> , Noet.
<i>Cancer</i> sp.
<i>Myliobates</i> sp.
<i>Carcharias gangeticus</i> , Müller & H.
<i>Galeocerdo</i> sp.
<i>Lamna spallanzanii</i> , Bonaparte
Number of forms common to each zone	5	8	5	11	17	32

From the above tables it is at once evident that the fauna from the three oilfields, Singu, Yenangyat, and Minbu, is different from that of any of the zones in the Upper or Lower Prome series or Kama clays (which represent the whole of the fossiliferous portion of the Pegu system in Lower Burma). Certainly they do not indicate a position between the zones of *Arca theobaldi* and *Cytherea erycina*.

From the dissimilarity of their fauna with that of the Nummulitic series, in Burma, and from the number of living species which they contain which are not known in any of the Pegu rocks of Lower Burma, it is fair to assume that they occupy a higher position in the stratigraphical scale than the zone of *Arca theobaldi* (situated at the base of the Kama clays). This view receives confirmation from the form *Lamna spallanzanii*, Bonaparte, which occurs in each of the three fields. It is synonymous with *Oxyrhina spallanzanii*, Bonaparte, and also with *Oxyrhina gomphodon*, Müller & Henle, and has been found to have the restricted range of Pliocene to recent times.¹ It is possible that the rocks in which it occurs may be high in the Miocene system, but it certainly proves that these rocks in which it occurs occupy a position high above that occupied by the zone of *Arca theobaldi* (base of the Kama clays).

In addition to the evidence given above there is that of the marine fossils found in the Yenangyaung oilfield by Mr. Pascoe and discussed by him in the *Records of the Geological Survey of India*, Vol. XXXVI, pp. 135—142. These fossils are of special interest; for, if Noetling is correct, they come from the horizon of the zone of *Cytherea erycina*, that is, from the base of his Yenangyaungian division. The vertical range of these forms through the known zones is given in the following tables, and I think that no one would say that they correspond to the zone of *Cytherea erycina*. The contention that the horizon from which these forms were collected is situated above the zone of *Arca theobaldi* is again supported.

	In Lower Prome series.	Zone of <i>Cytherea erycina</i> .	Zone of <i>Arca humerosa</i> .	Zone of <i>Pholas orientalis</i> .	Zone of <i>Paralid. prototortuosum</i> .	Zone of <i>Arca theobaldi</i> .	Not known in any of these zones.
<i>Rotalia</i> sp.	•
<i>Dendrophillia</i> sp.	•
<i>Arca theobaldi</i>	•	•
„ <i>myensis</i>	•	..

¹ Beiträge zur Kenntniss der Gattung *Oxyrhina*, C. R. Eastman, *Palæontographica*, XLII, 1894, pp. 189—191.

	In Lower Prome series.	Zone of <i>Gyth- rea erycina</i> .	Zone of <i>Artia humerosa</i> .	Zone of <i>Pholas orientalis</i> .	Zone of <i>Paral- lel. proto- tortuosum</i> .	Zone of <i>Arca theobaldi</i> .	Not known in any of these zones.
<i>Arca bistrigata</i>
<i>Nucula alcocki</i>
<i>Leda virgo</i>
<i>Cardita protovariegata</i>
" <i>visquesnelli</i>
<i>Lucina neasquamosa</i>
<i>Venus protoflexuosa</i>
" <i>granosa</i>
<i>Dione protophilippinicum</i>
" <i>protolilacina</i>
" <i>dubiosa</i>
" (<i>arrakanensis</i>)
<i>Tapes protolirata</i>
<i>Dorsinia protojuvenilis</i>
<i>Corbula prototruncata</i>
<i>Basilissa lorioliana</i>
<i>Solarium maximum</i>
<i>Turritella simplex</i>
" <i>acuticarinata</i>
" <i>lydekkeri</i>
<i>Calyptraea rugosa</i>
<i>Natica obscura</i>
" <i>gracillor</i>
<i>Sigaretus neritoideus</i>
<i>Oliva (Strephona) rufula</i>
<i>Strioterebrum unieinctum</i>
" <i>sp.</i>
<i>Terebrum smithi</i>
<i>Pleurotoma karenaica</i>
<i>Clavatula munga (?)</i>
<i>Balanus tintinnabulum</i>
<i>Carcharias (Prionodon) gangeticus</i>
<i>Twingonia</i>
Number of forms common to the zones	2	7	7	5	17	18	9

The fossil evidence, therefore, instead of proving that the shale series exposed in the various oilfields are the equivalents of the Upper and Lower Prome series, indicates that they are the upper development of the Kama clays and in this corroborates the view expressed in the previous pages. It also seems probable from the foregoing figures that the zone of *Arucia humerosa* is situated above the zone of *Pholas orientalis*.

Summary.

The points given in the preceding paper which are contrary to the views held hitherto are the following—

1. The oligocene age of the Upper and Lower Prome series and Sitsayan shales
2. The great thickness of Kama clays whose existence has hitherto never been suspected, giving the Kama clays a development ranging from Burdigalian to Pontian (from the base of the Lower Miocene to the Upper Miocene).
3. Noetling's correlation of the oilfields with Theobald's divisions in Lower Burma is contradicted by the fossil evidence
4. The indications that the Pegu rocks exposed in the oilfields are the upper development of the Kama clays, and that therefore they resemble in structure the exposure at Padaukpin.
5. The main oil-bearing strata seem to be the Kama clays (see the previous paper)
6. The magnitude of the unconformity between the Pegu and Irrawaddy systems, although it is hard to distinguish in any individual section.

Prospects of Oil.

Padaukpin and Banbyrn.—I have already discussed these rocks in detail, and although there is a much greater thickness of oil-bearing strata here than in any of the localities discussed in the

